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Developing Programming Skills Using Dynamic Adaptive Gamification in AI-Powered Learning Environments

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Abstract
The study was designed to measure the impact of dynamic adaptive Gamification in an AI-driven learning environment on the acquisition of Visual Basic programming skills, both cognitive and performance, by students at the industrial technical institute. The research was motivated by the observed weak Visual Basic programming skills among the students. The research sought to establish the effectiveness of the AI environment in enhancing programming skills. This aim was achieved using an experimental research design. Achievement test was the tool used in the pre and post-test method to assess the cognitive aspect of programming skills while an observation checklist was used in assessing the performance aspect. The sample of this research was a randomized group of second-year students of the Industrial Technical Institute consisting of 40 male and female students. Following the experimental intervention and data analysis, statistically significant differences were found between the pre- and post-test scores, in favor of the post-test scores in both the achievement test and the observation checklist for programming skills. From these findings, several recommendations were proposed, including the necessity of adhering to specified standards when designing Gamification and AI-supported learning environments, creating machine learning methods for analyzing student performance and providing immediate feedback to build programming skills, employing adaptive testing methods powered by AI for providing precise and individualized testing of student performance, and utilizing the current research findings on a practical basis for implementing dynamic Gamification in AI-supported learning environments for programming skill development.

Keywords: *Dynamic Adaptive Gamification, Adaptive Environments, Artificial Intelligence, Learning Analytics, Programming Skills*

Introduction

With the development in technology and use of information and communication technologies (ICT), it is now possible to develop educational systems that can understand and interpret the needs of each and every learner. Personal learning styles, levels of knowledge, weaknesses, and strengths are all considered by these systems. Artificial intelligence (AI) is employed with these systems in a way that they are able to modify educational content and activities automatically in a manner that a personalized learning experience may be provided for each student based on their needs.

Adaptive learning environments are superior to non-adaptive learning environments as they address shortcomings inherent in them. Non-adaptive systems are more cognitive in learning rather than skill-oriented learning, whereby there is a list of hyperlinks in non-adaptive content pages that are not sensitive to learners' needs, characteristics, learning styles, or previous knowledge. This can impose more cognitive load on students as they navigate through several content pieces

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and pages, finally not meeting educational goals for all students because of their variations (Zaric et al., 2017).

The adage "one size does not fit all" has been especially applicable in this regard. Adaptive learning systems allow for the creation of customized learning experiences for each learner through the analysis of their interests and behaviors. Through AI-based technologies, learners' performance metrics as they engage with learning activities and content are gathered and analyzed. This facilitates the delivery of tailored education content targeted at meeting their specific needs and optimizing their educational potential (Marbouti & Saadatmand, 2021).

Adaptive learning systems aim to provide a better learning experience for the learner by adjusting to personal needs, minimizing the adverse effect of social comparisons between students, and making students focus on personal growth and personal goals. By doing so, it seeks to minimize dropout and failure rates as a result of poor academic performance. Further, the environments are better at learning outcomes through the improvement of learners' engagement with learning content and the development of individualized learning environments according to their needs. These create self-learning skills and make the learner in charge of the learning process. Further, the environments apply AI when it comes to monitoring the performance of learners through statistics that identify their achievements and areas of weakness, hence improving their learning performance (Marbouti & Saadatmand, 2021).

AI has a key function to support adaptive learning systems to attain their learning goals efficiently. Being a sub-field of computer science, AI offers personalized learning material based on various student learning styles and implements effective assessment mechanisms and clear guidance to improve learning performance. AI further assists in interactive and bi-directional communication processes, promoting critical and constructive thinking competencies through simulations of reality, challenging discussions, and asking questions. With such strengths, AI becomes a vital ingredient in the crafting of sophisticated learning settings that can resolve issues as well as scale up the learning process to become more inclusive and human-oriented (Khosla & Kumar, 2021).

(Kamunya et al., 2020) highlight that just as content has been adapted to learners via adaptive learning environments, activities must also be developed to reach the learner. This is in alignment with the "one size does not fit all" concept in triggering the application of game elements that are applicable to learning styles in online learning systems. These elements are employed to augment the motivation of students, their engagement, as well as performance in the learning process under adaptive Gamification.

Adaptive Gamification is an emergent and rapidly developing research trend, extending traditional Gamification with adaptive and personalized motivational stimuli. These stimuli are adapted to the unique users' traits by integrating gaming mechanics into adaptive environments that are capable of accommodating learners' patterns and providing alternatives that increase learner motivation and focus (Böckle et al., 2017).

A few researchers have validated the effectiveness of adaptive gamification in achieving development of achievement, skill, creative thinking, and learning engagement. They are (Babu & Moorthy, 2024); (Manoharan & Nagulapally, 2024); (Hong et al., 2024); and (Narayanan & Kumaravel, 2024).

(Torres & Fernández, 2021) and (Hallifax, 2020) define two broad categories of adaptive Gamification: static adaptive Gamification and dynamic adaptive Gamification.

In static adaptive Gamification, adaptation occurs only once prior to learning environment users being allowed to utilize the environment. Equally functioning systems that utilize this approach adapt from the learner profile. These systems adapt by modifying game elements, establishing the learner profiles, and categorizing learners into various categories based on these profiles. Different game elements are then applied to each category of learners, as indicated by research by (Botíki & So, 2018) and (Kickmeier-Rust et al., 2014).

On the other hand, dynamic adaptive Gamification entails multiple adaptations throughout the learning experience. These systems adapt game elements with learner behavior either alone or in combination with the learner profile by modifying the performance of game elements. This type is illustrated in research by (Hassan et al., 2021); (Mora et al., 2018); (Roosta et al., 2016); and (Monterrat et al., 2015).

Considering the success of dynamic adaptive Gamification in creating various dimensions like achievement, skills, and various thought processes like problem-solving and creative thinking, this study aims to extend them to problem-solving in programming courses. Programming is one of the basic pillars of contemporary technology education, greatly enabling individuals to create computer programs and solve problems they face in their day-to-day activities. Coding does not only involve memorization of codes; coding is a creative activity that relies on a sound

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understanding of coding principles and rules, and therefore it is an effective tool for developing learners' logical and analytical thinking (Ayastuy et al., 2021).

2. Problem of the study

The analysis of student grades showed a clear deterioration in their performance. Because programming skills rely on managing commands, instructions, and code, it is critical to simplify these skills. Previous studies and literature have underlined the importance of adaptive Gamification in framing the content in a reduced form in order to cause a change in the behavior of learners, increase motivation, and optimize engagement for actualization of educational objectives in an adaptive situation that incorporates components of a game within an educational environment. Such stimuli thereby become suitable for the framing of tasks related to programming.

Numerous studies underscore the significance of performing more experimental research regarding adaptive Gamification. Some of these papers include (Holguin-Alvarez et al., 2025); (Asrifan et al., 2025); (Aldalur, 2025); (Scholz, 2025); (Shabadurai et al., 2024); (Hassan et al. 2021); (Hallifax, 2020); (Knutas et al., 2016); and (Monterrat et al., 2015).

Several conferences have showcased the importance of adaptive Gamification and called for further research. These include the International Conference on Computer Science, Engineering, and Educational Applications (2019) conducted in Ukraine on 26-27 January; the European Conference on Technology-Enhanced Learning conducted in the Netherlands from September 16-19, 2019; the International Conference on Electrical Engineering and Informatics conducted in Bandung on July 9-10, 2019; the 54th Hawaii International Conference on System Sciences conducted in 2018; and the 25th Conference on User Modeling, Adaptation, and Personalization conducted in Slovakia in July 2017. Apart from these, conferences such as the International Conference on Artificial Intelligence in Education conducted in Morocco from July 6-10, 2020; the International Conference on Applied Technologies conducted in Ecuador from 3-5 December 2019; the International Conference on Artificial Intelligence in Education conducted in London on 27-30 June 2018; and the International Conference on Teaching, Assessment, and Learning for Engineering conducted in Australia from 4-7 December 2018, have given importance to Gamification and artificial intelligence.

In light of the above sources, the current study problem lies in **"the inadequacy of programming skills among second-year students in the computer department of Industrial Technical Institutes."**

3. Questions of the study

Main Question:

How can an adaptive learning environment based on artificial intelligence be designed using dynamic adaptive Gamification to develop programming skills among students in Industrial Technical Institutes?

Sub-Questions:

1. What are the programming skills to be developed for students in Industrial Technical Institutes?
2. What are the foundations and standards required to design an adaptive learning environment based on dynamic adaptive Gamification to develop programming skills among students in Industrial Technical Institutes?
3. What is the proposed design for an adaptive learning environment based on dynamic adaptive Gamification to develop programming skills among students in Industrial Technical Institutes?
4. How effective is an AI-based learning environment with dynamic adaptive Gamification on the cognitive programming skill dimensions of students in Industrial Technical Institutes?
5. How effective is an AI-based learning environment with dynamic adaptive Gamification on the performance programming skill dimension of students in Industrial Technical Institutes?

4. Aims of the study

1. Develop a list of essential programming skills for students in Industrial Technical Institutes.
2. Establish a set of criteria for designing dynamic adaptive Gamification.
3. Design dynamic adaptive Gamification within an AI-powered adaptive learning environment.
4. Investigate the impact of dynamic adaptive Gamification in an AI-powered adaptive learning environment on developing programming skills among students in Industrial Technical Institutes.

5. Terminology of the study:

Operational Definitions

• **Adaptive Learning Environments:** A learning system through which technical school students can define their personal needs and learning styles, offering flexible programming content for their growth in skills and abilities through an interactive system and sharing of ideas.

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• **Artificial Intelligence (AI):** Intelligent systems that mimic human thought, being able to learn, adapt, and problem-solve, and individualizing education to suit students'needs.

• **Dynamic Adaptive Gamification:** Alteration of gaming elements depending on students' behavior in industrial technical colleges, specifically upon detection of strengths or weaknesses in their performance in programming.

• **Programming Skills:** A set of performance practices that allow technical institute students to learn programming skills with ease and effectiveness, as indicated by the scores achieved on an observation checklist developed for the purpose.

6. Theoretical Framework of the study

Theoretical framework of the study explains the following concepts: adaptive learning environments, artificial intelligence, learning analytics, dynamic adaptive Gamification, and programming skills.

First Variable: Adaptive Learning Environments

Adaptive learning environments represent a qualitative leap in learning, grounded in artificial intelligence and data analysis to deliver an adapted learning experience for each student. These environments take individual differences in learners into account, providing them with content and activities suited to their levels and abilities, optimizing learning outcomes and student motivation.

Components of Adaptive E-Learning Environments:

As stated by (Barbosa et al., 2024), adaptive learning environments are made up of the following:

- **Adaptive Electronic Content:** Learner-adaptable content, designed as an independent unit which can be configured differently from electronic content.
- **Self-Guidance System:** System utilized to guide learners to content appropriate to their level and existing knowledge, adapting study plans and recognizing areas in need of improvement.
- **Assessment and Feedback System:** A system used to quantify the extent to which learners achieve learning objectives and provide feedback to improve their performance and guide them towards goal achievement.
- **Learning Management System (LMS):** A system used to manage the e-learning process, like data and statistics related to learners and electronic content, and also managing instructions and guidance for learners.
- **Adaptive E-Learning Software:** Programs and tools used to develop and design adaptive e-learning environments, including electronic content design tools, self-guidance systems, assessment systems, and learning management systems.
- **Data and Statistics:** Data and statistics related to learners and electronic content and learning systems.

Advantages of Adaptive Learning Environments:

(Barbosa et al. 2024) and (Marbouti & Saadatmand, 2021) highlight that adaptive learning environments have numerous advantages, making them one of the most identifiable modern learning systems today. These advantages include:

• **Personalized Learning:** Adaptive learning environments facilitate personalized learning according to the aptitude and learning requirements of each learner.

• **Performance Analysis:** These environments facilitate analysis of the performance of every student, their weaknesses and strengths, and hence offer apt education.

• **Motivation and Interest:** Adaptive learning environments comprise learning games that encourage students, making them more interested in learning and desiring them to continue further.

• **Interaction and Communication:** These environments facilitate interaction between students, teachers, and trainers, enabling communication in various manners, making learning more effective and outcome better.

• **Experiential Learning:** Adaptive learning platforms enable practical and interactive learning, trial-and-error learning, which improves learning effectiveness and students'understanding.

• **Better Interaction:** These platforms offer students a chance to interact with learning content and reshape it according to their needs and levels, which promotes engagement and participation.

• **Adaptation to Student Needs:** The system is able to track student behavior and individual learning needs, adjusting the learning presentation accordingly (Kothari & Rangaswamy, 2020).

Second Variable: Artificial Intelligence (AI)

Amid rapid technological transformations in education, artificial intelligence (AI) has become a hopeful and intriguing issue in the education world. AI is a modern technology with the goal of developing sensible systems that can analyze information, learn from it, and decide on the basis of this analysis. It brings new possibilities to enhance the process of learning as well as enrich the learner's experience. AI can be used to provide customized learning content depending on individual students' learning needs and style. It also enables effective

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evaluation systems and prompt counseling to increase students' academic performance (Huang et al., 2021).

Features of Artificial Intelligence:

According to (Roll & Wylie, 2016), AI bears numerous features that make it a highly productive investment. These are:

- tapping intelligence to address problems despite having little information.
- Acquire and apply knowledge.
- Learn and be knowledgeable through experience and decisions.
- Apply past experiences and apply them to new contexts.
- Respond quickly to new contexts and situations.
- Handle complex and challenging situations.
- Handle ambiguous situations in which there is insufficient information.
- visualize, create, and comprehend visual information.

Types of Artificial Intelligence:

(Huang et al. 2021) further states that AI can be defined in three forms based on its capabilities:

• **Narrow AI:** Driverless vehicles, speech or image recognition programs, and chess games on mobile phones are examples. These are machine learning and deep learning-based systems and are teeming with all kinds of exciting innovations.

• **General AI:** It is characterized by machines possessing the same intelligence as humans, capable of performing any task.

• **Superintelligent AI:** Exceeds human intelligence and can perform tasks in a superior way than trained and expert humans. It can learn, communicate independently, plan, and judge.

Third Variable: Learning Analytics

Learning analytics has attracted significant interest in the education industry, an innovative method of understanding and improving learning activities. Learning analytics includes data analysis and interpretation of the educational process, such as novel ways to understand learners and utilize their resources effectively. The amount of data on learners constantly increases provides opportunities for the growth of activities and areas related to learning analytics (Wafaa Abdel Fattah, 2019).

Structure and Learning Analytics Components:

(Mining, 2012) identifies that learning analytics comprises the following components:

- **predictive Model:** Collects data from student interaction with the environment (e.g., hours, errors made, responses to questions, time taken on activities, grades, questions, and social network conversations). It also includes learner data kept in the learner model (e.g., learning preferences, interests, and background). It aims to track student progress, predict future performance, and measure the likelihood of success or failure in learning.
- **Adaptation Engine:** Processes data, information, and reports from the predictive model to provide content suitable for the level of the learner, enabling constant learning and dropout prevention.
- **Intervention Engine:** Intercedes at the right time to guide learners who are about to fail.
- **Dashboard:** Uses reports generated by the predictive model to provide feedback on the status of the learner to administrators, teachers, and learners themselves, reminding them of their progress.

Learning Analytics Significance:

(Divjak & Vondra, 2016) explain the importance of learning analytics in the context of:

- Individualizing and personalizing learning using content specific to every individual learner, addressing knowledge gaps, and focusing on individualization of the learning process.
- Defining learners' future actions and intervening at the optimal time in a way that enables tailoring of learning pathways.
- Offering timely intervention and assistance to the learners.
- Creating appropriate learning experience and improving quality of learning design and course planning.
- Time management of instructors by making available information to identify some learners who require support.
- Analytics in adaptive learning systems to design suitable learning experiences and provide adaptive, immediate feedback for enhanced learning.

Fourth Variable: Dynamic Adaptive Gamification

Dynamic Adaptive Gamification:

Dynamic adaptive gamification utilizes learner action to modify game features, individually or in conjunction with the profile of the learner. Dynamic adaptation depends on learners' behavior with the learning content or how they operate the whole system. Dynamic adaptation occurs many times throughout learning activity through adjusting

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game features or adjusting the manner in which they behave (Shabadurai, Chua, & Lim, 2024).

Characteristics of Dynamic Gamification:

(Paiva et al., 2016) and (Ayastuy et al., 2021) list some characteristics of dynamic gamification, i.e.:

- Adjusting performance of game elements by adapting.
- Declaring each action by learners as collaborative, individual, or social interaction.
- Dynamic adjustment of the system to match the nature of goals the learner is provided with according to actions.
- Renewing content, resources, and activities through ongoing analysis of learners' performance and needs.
- Implementation of AI and data analysis techniques to monitor learner interactions and offer personalized and optimized Gamification.
- Meeting the distinct requirements of each learner and providing a suitable learning experience based on their level and skill.
- Designing assessment and progress tracking mechanisms to guide students and providing custom instructions and comments to help students achieve their objectives.
- Providing interaction and co-operation between students, instructors, and peers.
- Using modern tools and technologies to create a living and evolving game world.

Requirements for Designing Dynamic Adaptive Gamification:

(Hallifax et al., 2019) and (Lavoué et al., 2018) identify the following requirements for designing dynamic adaptive gamification:

- **Player Knowledge:** An effective method of collecting and analyzing player data, such as skill level, preference, and play style. Machine learning and AI can be used for analysis.
- **Constant Availability of Data:** Monitoring the performance and interaction of players at all times in order to determine performance and refine the gaming experience as a result. This can encompass statistics, interactions, and pivotal decisions on the part of the player.
- **Dynamic Adaptation Systems**: Complex systems and mechanisms for enabling adaptation in the game depending on player performance. Such systems can consist of adjusting difficulty in the game, altering objectives, and rewarding and incentivizing in accordance with the player's development.
- **Flexible and Modifiable Design**: The game design must easily be flexible and modifiable so that it meets the needs of different players. This can include altering levels, adding new aspects, and adapting characters.
- **Immediate Feedback:** The game has to react immediately and appropriately to the activities and interactions of the player and provide timely feedback that serves to enhance the gaming experience and interaction.
- **Balanced Challenge**: Providing a balanced and appropriate challenge to the skill level of the player. The level of challenge should adapt in line with the individual players' building of skill and performance.

Techniques of Dynamic Adaptive Gamification:

There are a few approaches through which dynamic gamification may be accessed: systems that are based on learner activity only or systems that are based on learner activity plus the learner's profile, as follows:

1. Learner Activity-Based Systems Only:

Systems that only depend on learner activity change by adjusting the learner's performance. For instance, (Nikolopoulos et al., 2024) created a dynamic adaptive gamification-based educational system that depends on learner performance for adaptation. The system applies to a user profile to adjust game components based on the learner's attributes, with the profile updated over time. A prototype was developed and tested with simulated learner responses to evaluate its accuracy in tracking the profile. The results showed that the system performs well in varied use cases, effectively tracking user profiles and improving the learning experience and motivation of users.

In another study, (Jagušt et al., 2018) took into account the impact of three types of game-based learning activities (adaptive, collaborative, and competitive) on mathematics learning in lower primary students. Two second-grade classes and one third-grade class were employed for the sample, with the students' using tablets and digital lessons to learn. There were two instances of dynamic adaptation given:

• In the initial case, students' time in a mathematics test was altered. Every correct response reduced the time for the next question, in effect varying difficulty based on performance.

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• In the second case, learners were shown a target score that changed based on their responses. The more correct answers, the higher the target score.

2. Systems Based on Learner Activity and Profile:

In this, dynamic gamification is implemented based on learner activity and profile with predefined rules of adaptation. For example, Babu & Moorthy, 2024) proposed a dynamic adaptive gamification model for web-based training with the mapping of player types and game elements to their needs. The model tracks the progress of players and interactions with game elements over time, making the user experience better and fighting boredom. The research results confirmed that this adaptive approach enhances motivation and engagement in online training environments, with continued adaptation of game items based on player action and preference, producing a typically more effective learning process.

Fifth Variable: Programming Skills

The world is experiencing many developments based on knowledge and technological changes and economic globalization. These developments have greatly affected the nature and modes of production, and the kind of skills needed in the workforce. In order to address these developments and be competitive, our education system needs to be a source of high-level skills for the workforce and offer advanced educational and training systems based on technology.

Characteristics of Visual Basic Programming Skills:

(Mckeown, 2018) states that Visual Basic is a high-level, general-purpose programming language. It is easy to use due to the fact that it is a graphical user interface and a visual programming language. It contains an object-oriented development environment that simplifies it for programmers to write commands and conditions in fewer simple statements. It also allows easy tracking and correction of errors. Visual Basic supports a majority of computer systems and does not require other interpreters or compilers. Visual Basic is in the category of application generators, which enables one to interact with databases and include external controls within the application. Visual Basic has a user-friendly graphical interface, showing output on the screen and enabling the users to interact with them to perform required activities.

7. Methodology of the study

The current study seeks to address the issue of poor programming skills for students in the computer department of Industrial Technical Institutes through the application of dynamic adaptive Gamification in an AI-based learning system. The study employs a quasi-experimental research design (pre-test/post-test) on a single group. The study sample consisted of 40 second-year students in the computer department of the Industrial Technical Institute.

Study Tools:

1. **Cognitive Skills Test:** Developed by the researcher for measuring the cognitive aspect of programming ability. The test was validated and its reliability determined after being reviewed by expert judges. It was revised according to their views to be prepared for use. The test includes 50 objective questions: 30 multiple-choice questions and 20 true/false questions. Each question is worth one point, and the total score for the test is 50 points.
2. **Observation Checklist**: Designed by the researcher to measure the performance aspect of computer programming skill. The checklist has nine big skills, with 143 sub-skills. Student performance on the checklist is assigned a quantity, with a possible high score of 429 points. Performance is categorized into four levels: (1) Good, (2) Average, (3) Weak, and (4) Did Not Perform. A checkmark is placed beside the level a student performed if the student did perform a task.

Environment Design:

The (El-Desouki, 2015) instructional design model was followed to architect the learning environment according to a set of predefined criteria. Learning analytics were used to analyze and track student behaviors in the environment to determine their learning style according to the Felder-Silverman model (Global/Sequential). This allowed for the customization of learning content and Gamification for each learning style, as explained in the following phases.

First: Identification of the Student's Learning Style (Global/Sequential) Based on the Felder-Silverman Model and Learning Analytics:

The system identifies and analyzes the student activities and interactions in the adaptive learning environment based on the student's learning style according to the steps as

outlined by (Mahmoud, 2019), as illustrated in Figure 1.

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"Analysis Data"	Model Dimensions							
Content Visit	Global	Sequential	Verbal	Visual	Intuitive	Sensing	Reflective	Active
Content stay time			+	-	+	-	+	-
Image and video visits					+	-	+	-
Text and audio visits			-	+				
Outline visit			+	-				
Example visits					-	+		
Self-Assessment visit					-	+	--	+
Self-Assessment stay time					-	+	+	-
Exercise visit					-	+	-	+
Forum visit			+	-			+	-
Forum stay time			+	-				
Forum post			+	-				
Navigation skip	+	-						
overview visit	+	-						

Non-patterned behavior/reaction	
Positively patterned behavior	+
Negative patterned behavior	-

Figure 1: Analysis Data and Its Relationship with the Felder-Silverman Model

As soon as the student logs on to the environment using their own username and password, they are presented with a series of windows, which determines their learning style based on their activity within the environment. The student is initially shown intro windows, which contain a "Next" icon along with a "Skip" icon on every window. This is followed by summary windows, which also contain "Skip" and "Next" icons. The system then calculates the frequency of the summary being visited, the frequency of the introduction being visited, and the frequency of the student skipping navigation. It then finds the average of each of these parameters and computes the average for each learning style.

The systemclassifies the learner as follows:

• If the AVRG (average) is less than 0.3, the student is weak in that style.

• If the AVRG (average) is greater than 0.7, then the learner is strong in that style.

Based on the score calculated by the system, the learning style (Global or Sequential) of the learner is determined. The system continues to monitor the learner and adjusts their style throughout their stay in the environment. This means that the content and adaptive Gamification are dynamically adapted to the learner's style, which evolves based on their activity in the environment.

Second: Designing Content:

Designing Content and Learning Media for the Global Learning Style:

For learners who have been found to have a Global learning style, the content is presented in an overview manner that highlights general concepts and their connections to each other. Mind maps, charts, and summaries are a few of the methods used to achieve this. The content is structured into modules that are connected to each other and cover wide topic areas, with feedback and summaries at the end of each module to integrate different concepts back into the overall picture.

The learning media specially tailored for Global learners is:

- **Educational Videos**: The videos present the overview of the content before delving into details, illustrating how different parts are connected to one another.
- **Text Files:** Created using programs like Microsoft Word, the material is organized into connected chapters and sections to provide an overview of the topic. Texts are supported with images and tables to assist in establishing the relationship between concepts. See Figure (2).

Figure (2): Designing Content for the Global Learning Style

Planning Content and Learning Materials for the Sequential Learning Style:

For students who possess a Sequential learning style, material is presented systemically and serially, along with step-by-step directions and procedures that build knowledge sequentially. The material is divided into linked learning stages where each step reminds the student of the previous step. Directions and practice exercises are provided after each step to create understanding, plus

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immediate feedback in order to correct mistakes and stabilize learning. After each set of tasks, summaries are given to make successive comprehension of concepts possible.

The learning media specific to Sequential learners are:

• **Educational Videos:** They present information in a logical sequence, starting with an overview and then moving step by step in a cumulative manner, with application opportunities after each phase.

• **Presentations**: Prepared using software like PowerPoint, the information is displayed on separate slides with a chronological sequence. Images, clips, and animations are added to explain concepts better and interactively. See Figure (3)

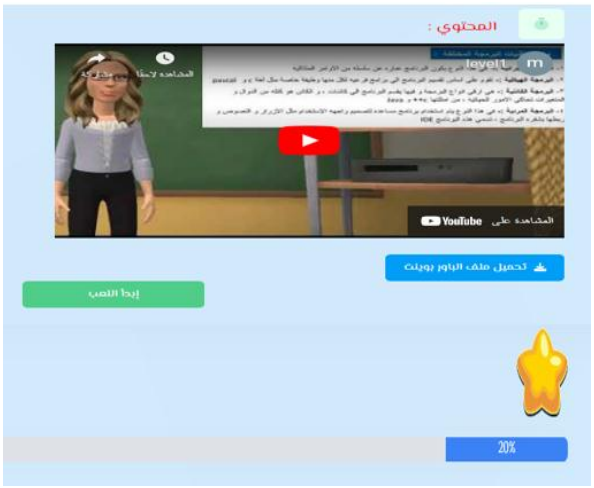

Figure (3): Designing Content for the Sequential Learning Style

Third: Determining Gamification Elements Suitable for Learner Styles:

To identify Gamification elements compatible with learner styles, studies and results related to adaptive gamification in higher education were analyzed and discussed, as in the study by (Zaric et al., 2017). Elements of gamification that positively impact learner styles according to the Felder-Silverman model were extracted. See Table (1).

Table (1): Gamification Elements with a Positive Impact on Learner Styles According to the Felder-Silverman Model

Element	Active	Reflective	Visual	Verbal	Sequential	Global	Sensing	Intuitive
Badges	x	x	x		x	x	x	x
Leaderboards	x		x		x	x		
Experience	x		x		x	x		
Points								
Puzzles		x	x				x	
Levels	x	x	x	x	x		x	
Stories	x	x		x	x	x		
Feedback	x	x	x	x	x	x	x	x
Time Path	x		x		x			
Progress Bar	x	x			x			
Quizzes	x	x		x	x			

Fourth: Monitoring Student Activity in the Environment:

At the end of each topic, once all concepts have been discussed, activities and adaptive Gamification appropriate to the student's style are presented. The student continues to accumulate points and badges during activities, tests, and assignments. The student can repeat these activities until 100% mastery is reached.

- If the student scores 100% on the first attempt, they move to the next level.
- if the percentage is less than 100%, the system advises revising the content or retaking the test.
- The student proceeds to the next level if they achieve 100% on the second attempt.
- if the student achieves less than 100% on the third attempt, the system allows the student to email the teacher, WhatsApp, or schedule a phone call for one-on-one guidance prior to retaking the test.
- If the situation happens again and the student scores less than 100% on the fourth attempt, the system sends an email to the teacher through the platform with full analytics of the student's performance, including time spent in the environment, login/logout, and weaknesses and strengths.

8. Practical Steps

- Preparing for the Experiment: The experiment began after ensuring that the environment was appropriate to be enacted within. A pilot stage and refining the environment based on the outcome of the latter was undertaken. The enactment included several steps, like obtaining all the

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requisite authorization from the concerned authorities to implement the study experiment.

- **Preparation and activation of student login information:** Student accounts were activated and prepared in the basic research groups for every student such that they were prepared and running well to log into the AI-based adaptive learning system

- **Application plan for the programming skills content**: A plan was prepared for the actual implementation of the programming skills content, and the experiment was implemented over 9 weeks during the second semester of the academic year 2023-2024, at the Industrial Technical Institute's computer lab in El-Mahalla El-Kubra, The application plan for the study experiment is given in Table (2) as follows.

Table (2) Timeline for implementing the experiment.

Time period	Study content through an adaptive gaming stimuli environment
10/2/2024	Students were interviewed to learn about the study topic, the environment, its objectives, importance, tools, how to register and log in, activities and how to implement them and navigate the environment, and to agree on a date for implementation.
13/2/2024	each student was given a password and username to enter his group's environment at the link: https://drsamar.ekosysco.com/
17/2/2024	Students start logging into their environment with their own environment link.
18/2/2024	Pre-application of study tools (cognitive test - observation card)
19/2/2024	Students interact with the environment and educational units, and implement activities for each level.
23/4/2024	Post-application of study tools (achievement test - observation card)

Materials used: An adaptive game trigger-based learning platform. Content and activities are organized according to the Fielder-Silverman Learning Styles Model (Holistic/Sequential). It includes adaptive Gamification triggers (points, badges, progress bar), and assessment tools (summary test, observation card).

Formative assessment: Formative assessment had several mechanisms built into the e-learning platform. After each unit or section, students were tested with short true/false, short multiple-choice questions, or matching tests to capture their momentary concept grasp. Such testing was enhanced by providing instant direct automated feedback after each answer and after completing a test. This feedback showed the correct response, with the complete explanation of the rightness or incorrectness of the given response, and linked it to relevant learning resources to promote understanding. The students also had the option to retake the test after practicing the material or receiving additional help, which encouraged self-study and rectification of errors. In addition to the tests, there were brief, content-related practical exercises, for instance, coding code snippets. The students could also post their programming projects for marking by the lecturers. There was also room for student-to-student interaction and query on obscure points, with the lecturer also posing questions and responding to answers from the students. Finally, students' success in completing a number of levels, tests, and activities was tracked by a dashboard that sat in the middle, clearly displaying their success.

Teacher's role: There were some key roles that the teacher was exercising. The teacher initially exercised the role of guide and mentor by clarifying the study objectives, showing the way to move around the adaptive environment and AI facilities, providing the login credentials, and guiding the students through their initial experience of using the platform. They later supervised and monitored students' use of the environment and recorded their observations. Whenever there were any issues or problems, the teacher also played a role of a facilitator and guide by providing solutions and individual guidance to students based on automated analysis reports.

The role of the learner: The role of the learner was to interact actively and effectively with the learning environment and the learning content. The students logged into the learning environment, moved through the learning modules, and participated in various activities. They also demonstrated keen interest in both competitive and collaborative exercises through getting involved in the completion of exercises and projects, and earning badges and points. In addition, students played a significant role in providing feedback that contributed to the improvement and development of the learning environment.

9. Learning Experience Evaluation (Impressions):

- **Positive Impressions**: Students praised the gamified learning environment for being easy to use and the simple interface. They repeatedly stated the simplicity of using content through the learning environment. Preparing beforehand for tests and watching videos to encourage students had a positive impact. Clearness of the learning content in the learning environment and simplicity of use for students and features thereof were also positive. The organization of the shapes, lines, graphics, media, and

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their size and color were also good. The organization of the learning environment and availability of the learning content were also easy, so it was easy to complete homework and learning units within a short time. Students also stated that the organization of the learning environment allowed them to understand and navigate through the learning content. The grade by level, badge and points, and the progress bar were useful features.

- **Barriers and Solutions**: When implementing the experimental treatment, some students encountered some barriers during their study, including the lack of internet service at their homes. This barrier was overcome by subscribing to an internet package. Additionally, some of the students' mobile devices were out of order, forcing us to work in the Industrial Technical Institute lab. Certain students encountered technical issues that impacted their overall perceptions of the usefulness of the learning platform. The most common technical issue encountered was the platform's loading time, as students complained that "it won't always load, which is a bit frustrating," and that "loading always takes a long time, regardless of location or device used."

- **Acclimatization to the Learning Environment:** Some of the learners during the early phase of learning utilized some time in acclimatizing to using the environment. Due to the flexible nature of the environment, whose layout is clicked, the students are able to easily circumvent any obstacle and learn how to use the environment very efficiently. As reported by the students, the progress bar, badges, points, and rewards had a significant influence on their performance and retention during the learning process.

- **Positive Interaction and Progress**: Throughout the study, positive interaction with the learning environment was witnessed since the students responded well to challenges and continued to adjust to the environment, ensuring that learning remained stimulating and exciting. More student involvement in learning content and a significant improvement in academic performance were observed. A number of the student impressions documented within the study sample were that they were eager to enter the atmosphere and persisted in attempting to access levels with so much difficulty. They acquired badges and points, and there was interaction and involvement through competition, challenges, and winning and losing among students to obtain as many badges as they could and acquire as many points as they might. There was also a feeling of fun and enjoyment among the students in the environment, and they were eager to learn more.

In all, the process of learning within the adaptive learning environment was profitable and rewarding. The students benefitted from the orchestrated environment, the various stimuli presented in terms of games, and the format and interaction possible that enabled their intellectual progress as well as gaining fundamental life skills.

10. Results of the study.

1. Response to the First Question:

To respond to the first question, which was written as, **"What programming skills need to be mastered for students of industrial technical institutes?",** a search for available studies and literature on programming skills required for students of industrial technical institutes was conducted. A list of programming skills in Visual Basic was compiled. The compilation was submitted to expert reviewers and then finalized based on their comments until the final compilation was established.

2. Response to the Second Question:

While answering the second question, that is**, "What are the principles and standards required for designing an adaptive (dynamic) gamification-based learning environment to develop students of industrial technical institutes' programming capabilities?",** the existing research and studies on adaptive and dynamic gamification were analyzed. A criteria list was developed and presented to expert reviewers. The list was revised according to their opinions and suggestions until the last criteria were established. These include:

- Documentation of the adaptive learning environment, controls, ethics, and intellectual and legal responsibilities.
- Characteristics of the target learners.
- Educational objectives.
- Appropriate links.
- Multimedia and its relevance to the education content objectives.
- Instructional design standards.
- Production of adaptive learning environment resources and processes.
- Support for the adaptive learning environment via artificial intelligence applications.
- Design of activities.
- Educational content.
- Support and assistance.
- Learner assessment tools.
- Availability of feedback**.**

1. Answer to the Third Question:

To respond to the third question, **"What is the proposed design for a learning environment based on adaptive**

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(dynamic) gamification to develop programming skills among students of industrial technical institutes?", discussion of the instructional design models for adaptive learning environments and gamification was conducted. The El-(Dessouki, 2015) model was selected. The following are the stages included in this model:

- Input evaluation stage.
- Preparation stage.
- Analysis stage.
- Design stage.
- Production stage.
- Evaluation stage.
- Implementation stage.

4. **Answer to the Fourth Question:**

The fourth question is: "What is the effectiveness of an artificial intelligence-based learning environment following the adaptive (dynamic) gamification approach on the cognitive aspect of programming ability among students of industrial technical schools?"

In answer to this question, the following hypothesis was established to serve as a response to this question**: "There is a statistically significant difference at the level of significance (≤ 0.05) between the pre- and post-test mean scores in the cognitive achievement test in developing the cognitive dimension of programming skills of the experimental group students, favoring the post-test."**

To confirm if this hypothesis is true, the mean scores of performances on the cognitive achievement test (pre-test/post-test) were contrasted using a t-test for the experimental group in the construction of the cognitive aspect of programming skills. The mean and standard deviation were also calculated for the experimental group on the programming skills achievement test, as shown in Table 3

.**Table 3: Significance of Differences between the Pre- and Post-Test Mean Scores of the Cognitive Achievement Test for Programming Skills among Students in the Experimental Group**

Group Name	M	SD	N	DF	T	Sig
Pre-Test (Experimental)	9.90	1.33	40	39	50.839	Significant at 0.01
Post-Test (Experimental)	45.00	4.038	40	39		

5. **Answer to the Fifth Research Question:**

The fifth research question is: **"What is the effectiveness of an artificial intelligence-based learning environment incorporating adaptive (dynamic) game rewards for programming skills' performance dimension among students in industrial technical institutes?"**

To answer this question, the second hypothesis was written as follows: "There is a statistically significant difference at the significance level ($\alpha \leq 0.05$) between the pre- and post-test application mean scores of the experimental group in the performance of programming skills in favor of the post-test application."

To verify the validity of this hypothesis, the mean performance scores in the programming skills observation checklist (pre-test/post-test) and the experimental group's standard deviation for the programming skills performance observation checklist were checked using a t-test, as presented in Table 4.

Table 4: Significance of Differences between the Pre- and Post-Test Mean Scores of the Programming Skills Performance Observation Checklist for Students in the Experimental Group

Group Name	M	SD	N	DF	T	Sig
Pre-Test (Experimental)	66.85	10.134	40	39	119.093	Significant at 0.01
Post-Test (Experimental)	405.60	15.455	40	39		

Discussion of the Results:

As is evident from Table 3, there is a vast difference between the pre-test and post-test uses for the experimental group, in favor of the post-test. The pre-test use had a mean value of 9.90, which is significantly lower compared to that of the post-test use at 45.00. The difference between the means is statistically significant, since the t-value (50.839) calculated is larger than the critical t-value at 0.01 level. This verifies the hypothesis acceptance. These results can be interpreted as indicating that the pre-experiment cognitive experiences of the students were less mature than their post-experiment experiences. Furthermore, this is a significant indicator of the contribution made by dynamic game incentives in the adaptive learning system based on artificial intelligence to enhance the cognitive aspect of programming competence.

Similarly, Table 4 reveals a huge difference between the pre- and post-test application of the experimental group. The mean score of the pre-test application was 66.85, which is much lower than the mean score of the post-test application, which was 405.60. This enormous difference between the means is statistically significant because the calculated t-value (119.093) is larger than the critical t-value at the 0.01 level of significance. This further verifies

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the acceptance of the hypothesis. This indicates that students' performance skills prior to the experiment were weaker than after the experiment. This also signifies the crucial role performed by dynamic game incentives in the adaptive learning platform based on artificial intelligence in enhancing students' performance skills.

With such information in hand, it is evident that adaptive dynamic game incentives, if used in an artificial intelligence-based learning system, play a pivotal role in programming skill development among industrial technical institute students. The incentives enhance the learning process by personalizing challenges and activities according to learners' requirements, thereby making them more engaged with the learning material and motivated to achieve tasks effectively. This aligns with the results of studies done by (Shabadurai et al., 2024); (Kotsopoulos et al., 2024); N(ikolopoulos et al., 2024); (Hallifax et al., 2019); and (Jagušt et al., 2018).

11. Recommendations of the study

- Design and develop educational curricula based on dynamic adaptive gamification
- Design educational activities based on learners' learning styles
- Train teachers to design dynamic adaptive learning environments

12. Proposed Future Research:

- Conduct a study on the interaction between static/dynamic game incentives and individual/collaborative learning modes in adaptive learning environments and their impact on the development of programming skills and self-efficacy.
- Investigate the interaction between static/dynamic game incentives and player types and their impact on cognitive achievement, performance skills, and technological acceptance.
- Conduct future studies to expand the use of dynamic incentives across various educational levels and scientific disciplines to enhance the quality of digital education and foster 21st-century skills.

Ethical Approval Declaration

"All procedures involving human participants in this study were conducted in accordance with the ethical standards set by applicable research guidelines and the principles of the 1964 Declaration of Helsinki and its subsequent amendments. Ethical approval was secured before the commencement of data collection."

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Data availability:-

The datasets generated and analysed during the current study will be available from the corresponding author upon reasonable request.

Consent for publication:-

I hereby provide consent for the publication of the manuscript detailed above.

Competing interests:-

The authors declare no competing interests.

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