The Main Aspects of Adaptive Educational Games for Normal and Disabled/Disordered Learners: A Comprehensive Study

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***Abstract*— Gamifying the educational systems implies the application of gaming rules in a non-gaming context. This has positively-affected the success and engagement of learners in the learning process. The learning styles work as an important factor for a better definition of the preferred way for a learner to learn, resulting in an adaptable system that understands the educational needs of the learner, with adaptable teaching styles that draw his attraction to continue learning. In this paper, we discuss the state-of-art principles needed for serious gamification, and investigate the main concepts required to create adaptive educational systems. This includes the study of the adaptation types considered for both normal and disabled/disordered learners, as well as building a detailed comparison between the different evaluated educational models, while highlighting the concepts applied and analyzing their strengths and weaknesses.**

Keywords—E-learning, Educational Games, Serious Games, Gamification, Adaptation, Learning Style, Adaptive Educational Models.

I. INTRODUCTION

The evolution of technology has led to a generation with different desires, social interaction, and even different learning preferences than their parents [1,2,3]. Many refer to this generation as digital natives [4], net generation [5], or gamer generation [6]. E-learning systems are a replication of the traditional learning experience, the classroom [7,8]. The power of educational systems over a classroom is related to the wider sector of students that they can serve, having the leisure of time and accessibility, unlike the time constraint, deadlines, and learning duration limitations in the classroom. On the other hand, one-to-one educational method is considered to be the optimal setting for obtaining desired outcomes and behaviors from the students [9]. Bridging the gap resulted from the lack of the teacher role is a necessity for the e-learning systems to survive [9].

Overcoming the gap can briefly be achieved by encompassing adaptation in the educational systems. Adaptivity has proved to be a successful addition influencing the student's success in the learning process, motivating them for better achievements [7,10,11,12]. Adaptivity is said to be the way that educational systems follow in selecting materials that is best suited for each individual learner, in which adaptation can have several types [7,13,14]. Accordingly, adaptation is the concept of (i) understanding the learner's needs, (ii) evaluating the performance done by the system and the learner, and (iii) modifying and adjusting the educational/learning process provided to the learner according to that evaluation. The same process can be applied to both normal and disabled/disordered learners. The only requirement is to cross the types of disabilities with the types of adaptation required for each.

The learner's preference is the learner's preferred way of receiving, processing, and understanding the information, which is referred to as the learning style [15,16,17]. For example, one learning style can be that a learner may prefer graphs and pictures than text, or that she/he prefers the trial and error method in solving or practicing, rather than thinking it through. Therefore, it can be deduced that each learning style should have a corresponding teaching style reflecting the best way of presenting a piece of information to the learners. Therefore, the presentation of relevant preferred content with a clear learning path, that is, a clear sequence of goal-oriented challenges, has shown to be the best motivating factors for learning [18]. Deducing the correct learning style for each learner is gradually derived from trying different teaching styles and observing which way(s) had resulted in the best outcomes. This evaluation works as a feedback mechanism for both the learners and teachers. The learners consider feedback as an interesting component that needs to be included in the learning platform [1,2,3,30,36,46]. This is considered as the main requirement to have an adaptable educational system. Thus, educational models have different combination of such requirements to achieve optimal performance from the learner's side.

On the other hand, computer games have engaged the individuals' interest in ways that kept them in deep concentration and enjoyment for extensive periods [21,23,24]. This has attracted researchers to gamify the educational

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process for more desired outcomes and successes, considering the engagement as the best indicator to the learning process [23,24,25]. This can be referred to as educational games or serious games [23,26]. The learning process naturally occurs while playing, as the learners require stretching their skills to the limit for accomplishing a challenging goal [23,27]. Keeping them consciously indulged, focused and completely absorbed, is a state called flow [20,33]. Flow is described as one of four psychological states resulted from a differing combination of challenges' and skills' levels (high or low) [23]. The four states are: (i) apathy state, due to low level of challenges and skills, (ii) relaxation state, due to high level of skills but low level of challenges, (iii) anxiety state, due to high level of challenges but low level of skills, and finally (iv) flow state, due to high level of both challenges and skills. As a result, the learner's scores obtained from the gamified learning processes overcome that of the regular lessons with a significant difference, implying that through games and engagement, an educational material will be best presented and received [1,7,23,26-35].

The purpose of this paper is to investigate the influential aspects of an effective adaptive educational/serious game, defining the relationships between such different aspects. A comprehensive discussion is provided for the main models that have adopted variant adaptation concepts. Furthermore, an extensive comparison is conducted between the presented adaptation models to evaluate the aspects applied in each. The rest of the paper is organized as follows. Section 2 demonstrates the most important aspects for adaptive educational games. Section 3 discusses the adaptability in selective models and their main components, while presenting a comparative analysis with respect to the main parameters. Finally, section 4 summarizes the conclusion of this study and introduces our future work.

II. IMPORTANT ASPECTS FOR ADAPTIVE EDUCATIONAL GAMES

A personalization taxonomy with the most important parameters of e-learning systems was illustrated in [36]. The following sections thoroughly discuss the main parameters along with the gamification concept in a full scale.

A. Gamification

Gamifying the educational systems means including the game design elements and rules in a non-game setting [19,25,37]. Gamification of learning materials helps in the establishment of abstract thinking and the development of cognitive functions [38,39]. It turns the exercises into fun activities and learners into players, which helps to encourage the desired behavior and performance from the learners, i.e. to keep them engaged and in the flow state. According to [21], engagement can typically be branched into three types; behavioral engagement, which is related to the extent of involvement in educational activities and on-task behavior. The second type is emotional engagement, which includes the positive and negative reactions to the learning process. Thirdly, cognitive engagement, which is related to the eagerness and willingness of the effort the learner cares to apply for mastering difficult skills. For the students to stay motivated, in the flow state, and in the engagement state, the educational system must abide to certain principles and dynamics [23,26,29,30,31]. Several studies have considered the dynamics required for the desirable learners' behaviors and the corresponding game mechanics, which are integrated and illustrated in Table I [18,19,37,40].

Game mechanics are the mechanisms and tools used to gamify the activities in the educational systems, whereas game dynamics are the motivations that lead to desired emotions resulting in engagement [26]. For instance, in game mechanics, levels and challenges are related in such a way that the game consists of progressive difficulty levels with different types of challenges [23]. This perfectly serves three critical issues, the learners are kept in an engaged flow state, the learning material with different topics and exercises can all be organized to fit the different levels, and that learners can keep track of their status striving for more achievements, which are reflected in the corresponding game dynamics. The status in a simplified definition is the form of aggregated points rewarded to the learner with each finished task [26]. Thus, the points and rewards in Table I are the simplest and basic form of evaluation in the educational/serious game. Another mechanic is the implementation of a background fictional story to help keeping the fun and flow state [7,41]. For an optimal experience, the activities need to be goal-oriented, directed, and presented in a sequence, so that each challenge should have a specific goal with a specified difficulty level [21,38,42]. The status and competition are two forms of the feedback mechanisms. Status defines the evaluation of the learner for a single learning object (LO), while competition indicates the knowledge level reached for each learner compared to all the learners registered in the course, presented in the form of leaderboards. Achievements can be translated to the difficulty levels or more advanced materials of the course, so that as the knowledge level of the learner increases, the difficulty level of the course increases.

B. Learning Styles

After configuring the system with the gamification concerns, the system then needs to establish a way to understand its users, which is the first step of adaptation. The learner's different backgrounds, learning and mental abilities impose the demand to create a classification model for the different types of learners [11]. Several researchers have developed adaptive educational systems based on various models [10,12,17,36,43-45]. Gender, learning motivation, cognitive style, and learning style were considered as the four factors in which learners can be classified [42,45]. Among all the proposed classification factors, the student's learning style has been proved to be an important factor, as it reflects the learner's preferred behavior of learning [17,46-50]. It also allows building a corresponding teaching style that is applicable for each learning style. There had been many proposed learning styles theories [46-50]. However, the widely adopted model is the Felder Silverman Learning Model (FSLM), which defines the different dimensions of a learner in an organized manner from which teaching styles can be interpreted [46].

TABLE I. GAME DYNAMICS AND MECHANICS

Game Dynamics	Game Mechanics
1. Reward 2. Status 3. Achievements 4. Competition 5. Learning through intense enjoyment and "fun" 6. Contextulized, goal oriented instead of abstract learning.	1. Points 2. Levels, paths, and progress 3. Challenges/ Progressive difficult levels 4. Leaderboards 5. A fictional setting or fantasy 6. Clear but challenging goals.

TABLE II. LEARNING STYLE ELEMENTS AND THE CORRESPONDING TEACHING STYLE

Dimension	Pole	Teaching Style
Perception	**Sensing:** prefer using existing ways than exploring new ways, prefer learning concrete materials, careful with details.	Detailed information, proofs, facts, data, results, more examples , case studies and exercises.
	Intuitive: prefer trying new ways, prefer learning abstract materials, not careful with details.	Concepts, hypothesis theories, principles, remove unnecessary details, exercises should have specific goal.
Input	**Visual:** prefer learning materials presented in pictures, charts or diagrams.	Exercises should involve videos, animations, charts, diagrams, tables, images, graphics and schemes.
	Verbal: prefer learning materials in audio and/or text, having difficulty with visual style.	Exercises involve more audio interactions, music, sounds, articles, texts.
Processing	**Active:** learn by doing and experimenting.	Experiments, trial and error projects.
	Reflective: learn by thinking it through.	More hints and tips, guidence steps for solving the exercises, exercises that need extra research and effort.
Understanding	**Sequential:** prefer learning small steps at a time, build from specific knowledge until a more general knowledge is attained.	Present exercises of each topic in the same order of the topics in the course.
	Global: prefer learning by jumping from one topic to another in a non-linear manner, prefer learning the general knowledge then learning s more specific knowledge.	Present all the topics for the learner to navigte freely between them.

Studies in [7,11,15,51] have explained and categorized each dimension, whereas [29] has adopted the understanding dimension only to be the main classification between learners for their preferred process for learning as a part of the proposed adaptive educational computer game. While the learning style describes the preferred way of receiving information, the teaching style defines the way to provide it. Examples of suggested teaching styles have been proposed in [52] for both the perception and input dimensions. Table II introduces the suggested teaching style for each pole as per each dimension. The learner is characterized by one pole from each of the four dimensions, such that she/he can either understand sequentially or globally, and prefers to receive information visually or verbally. Accordingly, the system should have many versions for the same topic or exercise, where each version corresponds to a specific teaching style. Thus, the material presented to the learner is usually a well-organized combination of the teaching style(s) that convey to the learner's preferred pole from each dimension, which has widely been defined as the learning objects (LOs).

C. *Learning Objects*

Most of the e-learning platforms are closed platforms, preventing their materials from being shared or re-used. Meanwhile, building an adaptive educational system involves adapting the teaching materials represented to the learner. This requires having pre-developed teaching materials meeting each teaching style, which is negatively-affected by the absence of the reusability adaptation. In [53], IEEE Learning Technologies Standardization Committee (LTSC) has established the Sharable Content Object Reference Model (SCORM) as the most popular e-learning standard that allows the reusability of digital contents as LOs. A LO was defined in [54] as a collection of assets, which are the digital representations of media, text, images, sound, assessment objects, Web pages or any other piece of data that can be delivered to a Web user. Therefore, when a LO is created, its teaching style is defined by choosing the appropriate assets matching the learning style of the targeted learner. Learning Object Metadata (LOM) helps to allocate, evaluate, and manage the LO [19]. Another important role of LOM is that it helps relating each LO to one another, allowing the system to have a comprehensive picture for all the LOs in a specific course [53]. Moreover, it facilitates the process of ordering the LOs according to their precedence, difficulty, and categorizing them according to their teaching style.

D. *Evaluation and Feedback Mechanisms*

At this stage, the system is comprehended that it needs to consider the learner's learning style, define a corresponding teaching style and choose the best assets' combination to form a group of LOs that models the course structure. The system is now loaded with courses, where each LO, representing many topics and exercises for the same learning objective, has different versions of LOs (for different teaching styles) that will be directed to the targeted learners. The system starts with the learners represented by randomly-chosen LOs, as no certain teaching style is yet defined for these learners. Thus, knowing their opinion on the recently taken LO helps for a more precise selection of LOs in the future. This derives for the necessity of creating a two-way feedback mechanism between the system and the learner. A feedback mechanism can also be created for the teachers/domain experts. An accurate evaluation of the

student's performance in a LO is the basic element for a feedback mechanism. Evaluation in its simplest form is the score given to the learner for his/her performance in the presented LO, indicating that the learner has succeeded in his goal [7,21,22]. If the score is high, then it can be concluded that this teaching style is acceptable by the learner, which is considered as the second step of adaptation. As elaborated in [20], the learning assessments are either summative or formative. The summative assessment (Delayed Feedback) is provided after the course is finished, as an evaluation to the overall performance of the learner in that course. The formative assessment (Immediate Feedback) to the ongoing exercise solving can either display the result (Knowledge of Result), offer the correct response (Knowledge of Correct Response), or provide guidance that helps to reach the result (Elaborated Feedback).

The learners' poor performance or low scores might not be due to presenting the wrong LOs, in fact it might be due to inattentiveness from the learner's side. A method has been presented in [52] to calculate the score of the learner in each dimension separately. The method compared the two poles of each dimension against each other to know the learner's preferred pole. The score included the LO's complexity/ difficulty level, the number of attempts to solve it and the time taken for solving. The final scores for both poles are compared, then the process is repeated with each LO and all the dimensions. This evaluation is the feedback returning to the system to be used by the learning style recognizer. Additionally, the poor performance might be due to other reasons, such as representing a difficulty level that is incompatible with the learner's knowledge level. As a result, the system is required to choose LOs that are more relevant to the learner's learning style, with an appropriate difficulty level, leading to the third step of adaptation.

E. Adaptation Types

Adjusting the presented materials implies knowing which aspect requires the modification, i.e. is it the content difficulty level? the way the information is presented? is it the sequence of exercises? Based on the performed evaluations, the system should infer what type of adaptation is required. The traditional and additionally-defined types of adaptation have been investigated thoroughly in [13,48,55], which are summarized in Table III. Changing the elements' properties of a LO is basically an adaptation in the interface, which involves the visual/verbal dimension. This is important, especially with the disabled/disordered learners, which will be discussed in further detail in the following section. Despite of altering the elements on the screen, the flow of the learning process controls the sequence in which the LOs of the same precedency level are presented with. The interactive problem-solving tracks the learner's behavior in the LO and helps to provide guidance. This can be through a domain expert or by a predefined set of rules that takes the form of help, hints, tips, etc. For the same topic, the difficulty level can be adapted to the knowledge level of the learner, which can also be done during the runtime by the means of rules or domain experts. As for the perception, the system can control the details given for each information by removing the unnecessary details for the intuitive, or adding more details and case studies for the sensory ones. The adaptation of the evaluation model can be important in many cases in order to adapt the weights of the different tasks in the LO.

TABLE III. THE REQUIRED ADJUSTMENTS AND THE CORRESPONDING ADAPTATION TYPES

Required Adjustment	Adaptation Type	Extended from
Usability adjustments and Input dimension (learning style adjustments)	Interface-based adaptation: related specifically to learners with special needs, includes object's properties like color, size, shadows, position of elements on the screen, etc.	
Understanding dimension (learning style adjustments)	Learning flow-based adaptation: related to the sequence of the presented content, tracks the learning process, also known as navigation support adaptation.	
Perception and processing dimensions (learning style adjustments)	Interactive problem-solving support: tracks the learning process by providing guidance for learners, which can either be a set of predefined rules or domain expert. This is important for the disabled/disordered learners.	Learning flow-based adaptation
Learner's knowledge level, learning ability, and Content difficulty level adjustments	Content based-adaptation: related to the content depth and difficulty level of a certain topic, also referred to as adaptive e-learning hypermedia adaptation.	
Content difficulty level adjustments	Changes on-the-fly: the content of pre-defined properties can be replaced with other content at the runtime automatically or by a domain expert.	Content based-adaptation
Perception dimension (learning style adjustments)	Adaptive information filtering: related to appropriate information retrieval, providing relevant output, including adaptive link hiding/disabling/removal, dimming fragments.	
Evaluation model adjustments	Adaptive evaluation: related to adapting the evaluation model.	

F. Adaptation for Disabled/Disordered Learners

Learners with disorders/disabilities need more focus and attention to engage them in educational/serious games. As the first step of adaptation is understanding the learner's behavior, the same is required for the disabled/disordered learners. The disorder/disability causes struggles and difficulties in the learning process. The types of disorders/disabilities and the adaptation types required for each has been discussed in [56], where it can be summarized as follows:

a) *Blindness:* total blindness relies on the hearing abilities for both receiving and providing information. Hence, the system must be adapted for screen reading, speech recognition, and voice commands. It is a form of

adaptive information filtering, and for reformatting the way the information is exchanged.

b) *Low Vision/Color Blindness:* it is mainly interface adaptation, adapting the elements' properties and screen, such as magnification. This includes as well high contrast rendering for color-blind learners. Color schemes and filters are also required.

c) *Hearing Disability:* better to present information visually, or add visual stimuli, text commands, etc.

d) *Motor Disability:* reduced to no hands mobility, which more relies on voice commands for input.

e) *Cognitive Disability:* learners that require adapting the difficulty, comlexity and the pace of the LO. It is mainly content adaptation.

Thus, a well-planned, comprehensive and organized adaptive model that includes all the adaptation types helps to be applicable and suitable for any learner with different abilities. All learners start with the same pace, and then keeps adapting itself to be personalized for each individual learner. In the following section, we investigate the main adaptive models that have been proposed in the literature.

III. MODELS OF ADAPTIVE EDUCATIONAL SYSTEMS

The previously explained aspects are the basic concepts on which an adaptive educational model can be built. These concepts are modeled to form the components of the system. Some main components are briefly clarified herein.

- Learner: also known as user, student, or player, is the user of the educational system.
- Learner Model: stores the learner's preferences, static and dynamic information gained through the interaction with the system, which is necessary for adaptation.
- Domain: connected and related topics under the same scientific area.
- Domain Expert: tutor/author, where not all the models include her/him as a part of the system, but if present, she/he is responsible for developing and receiving feedback on the LOs, forming a class group.
- Domain Model (DM): structures the content knowledge, which can be a tree-like structure with the content divided into topics and sub-topics. Each sub-topic has a clear learning objective, which collectively defines the topic's goal.

Most of the research studies applied only some selective concepts. For instance, some researchers have adopted the knowledge level and user profile information instead of the learning style [10,12,43-45], whereas others have incorporated the learning style with other learner models [46-50]. The same situation has been applied in the adaptation types, where only few types were mentioned in each model [29,57-62]. As long as the system is capable of delivering a personalized content to the learner and the learner shows improvement, progress, and achievements, the system is considered to be successful. However, knowing the adaptation types applied in each model gives a more descriptive picture to note the limitations of that system regarding the extensibility and flexibility of the model. The following is a consolidated analysis for some main selective models, highlighting their main strengths and weakness points, the applied adaptation types, learning style and the support for disabled/disordered learners. This is in an attempt to help building a generic model that applies most of the necessary aspects. They are categorized by the capability or incapability of supporting disabled/disordered learners. In addition, Table IV presents a comparative study for the main adaptive educational models, in which the models are evaluated in terms of specific parameters.

A. Models Supporting Disabled/Disordered Learners

A supervisor model (SM) was introduced in [59] as a part of the storage layer in the three-layered Supervised Adaptive Hypermedia Model (SAHM). This model interacted with the DM and UM to gather enough data to make adaptations to the content and learning flow. The gathered data along with some questionnaires act as the feedback mechanism. Changes-on-the-fly adaptation took place, as the domain expert can make changes in the DM at the runtime. Learning styles in general were considered in the UM. The changes on-the-fly adaptation would have been utilized by the role of domain expert, by which a new LO can be developed and presented. The detailed DM helps to build different difficulty levels, but the absence of interface adaptation and visual components allow only the cognitive disabled users to use the system.

A Learning style was considered in the Adaptive Intelligent Tutoring System (AITS) proposed in [61]. The implied instructional model acted as the Interactive Problem-Solving Support for learners in the learner model. The proposed adaptation was the adaptive hypermedia, in which the presentation adaptation adapted the content in the hypermedia page to meet the user's preferences, while the navigation support adaptation performed the adaptation to the learning flow process. These adaptations made it applicable for the Cognitive disabled learners to participate. The interface module can include additional components to allow interface adaptation. Furthermore, no DM was explained and no types of LOs and teaching styles were referenced.

A model was used in [62] as a base for the G-OALS analyzer application (G-Online Analyzer of Learning Styles), where a number of exercises was presented to analyze and evaluate the students' behaviors based on the number of attempts, complexity and duration taken to solve each exercise. This feedback mechanism was followed by the adaptation of the learning flow, as the domain experts prepared activities for each learning style. This adaptation was responsible for presenting the activities that match the students' preferences only. It was not mentioned explicitly the applied adaptation types other than altering the learning process, i.e., the learning flow, no usability adjustments, indicating that interface adaptation was not applied.

TABLE IV. COMPARISON TABLE FOR ADAPTIVE EDUCATIONAL MODELS

Models	Parameters				
	Adaptation Types	**Learning Style**	**Main Strength**	**Main Weakness**	**Can Support Disabled/Disordered Learners**
[29]	Learning flow	Understanding dimension only	Background fictional story, step by step and mission map guidance	Adapts to single dimension of the learner's learning style	X
[57]	Learning flow, content, and interface adaptation	√	Rated Learning Objects	Relies heavily on the learner's feedback on the learning object for maturing the system	X
[58]	Learning flow and content adaptation	X	System notifying domain expert when learner needs guidence	Non-generic domain model	Cognitive disabled learners
[59]	Learning flow, content-based and changes on-the-fly adaptation	√	Well-defined and organized generic domain model	Changes-on-the-fly adaptation unutilized due to absence of domain expert role	Cognitive disabled learners
[60]	Learning flow and content adaptation	X	The Affliate Model	Social platforms create conflict opinions	X
[61]	Learning flow and content adaptation	√	Instructional model	Not defined, well-structured domain model	Cognitive disabled learners
[62]	Learning flow	√	Learning style analyser	Adaptation for the learning flow only	Cognitive and hearing disabled learners

This excluded the blind and low-vision disabled learners. Even though, the applied evaluation methodology allowed for the precise definition of the learner's learning style, together with the presence of visual, audio, and kinesthetic teaching components. This gave the ability for cognitive and hearing-disabled learners to participate.

B. Models not Supporting Disabled /Disorderd Learners

In [29], the model has depended on the understanding dimension of the learning style only, stating that the only made adaptation was the sequential or global sequence of the learning materials. This did not help much the disabled/disordered learners. It was a simple model for normal learners, with a little adaptability affecting the learning flow only. For the sequential learners, a predefined step-by-step interface guided the learners. The same occurred for the global learners, where they were represented with a mission map. The model was game-based on a fictional story to help keeping the engagement.

In [57], a framework was proposed based on the User Response Theory, where a user feedback mechanism behind the adaptation of the learning flow, content, and interface adaptation was applied to reduce the computational cost-based on the case-based reasoning model. FSLM was the learning style adopted as a part of the learner preference model. The system heavily depended on the user for maturing the system. The main advantage about this is that it allows all the LOs to get rated, which acts as a feedback returned to the author for noting the status of the developed LO. This is helpful for many reasons, i.e. a low-rated LO will remain hidden in the learner's learning path, as representing it may falsely alter the learner's overall evaluation. In addition, it creates overload on the learner as well as deviating her/him from the learning process. This can affect the learner's engagement, resulting in a system that stays immature. Moreover, the adopted adaptation types can be applied for some kinds of disabled/disordered learners. However, the learning process is too complex for the disabled/disordered learners to use.

On the other hand, no learning style has been adopted in [58], in which the system has rather personalized the learning content to meet the learner's interests based on gathered static information. Dynamic information was also stored in the UM, reflecting the learner's behavior and performance in the course activities that took place in the content and learning flow adaptive model. Hence, a rule-based mechanism was implemented. Feedback mechanisms were developed to the tutor and to the student that recommends content to be explored depending on the student's behavior. A hypermedia module was used to build a non-generic DM. Although interface adaptation was not introduced, Cognitive disabled learners might be able to use the system due to the content adaptation. This would involve some modifications to the DM, but as the DM is non-generic, extensibility is difficult.

Another layered architecture was the two-layered system developed in [60]. An Affiliate Model was developed as a connection model to the Course Model and Content Model that creates social environment, allowing to share, like, comment, etc. between the users. Thus, it worked as an interaction between users as well as a feedback mechanism to the system. Adaptation in the learning flow and content was facilitated due to the presence of user Behavior Tracker at the Runtime Layer, in addition to the user's cognitive preferences and knowledge space. While the user interface contained navigational tools that may be adapted, the social interactive platform created a

barrier for the disabled/disordered learners. It is quite difficult for the disabled/disordered learners to socialize, as each of them required another way of interacting rather than likes and shares. In addition, observing other learner's achievements (normal or disabled/disordered) reduces their self-esteem.

IV. Discussion and Conclusion

The educational/serious games are e-learning platforms with the chance of having the learning experience in a game settings/context. For boosting the overall educational process productivity, the adaptation concept is merged with the gamified learning system. In this paper, a comprehensive analysis of the important aspects for developing an adaptive educational/serious game was presented, in which the gamification dynamics and mechanics, learning styles, teaching styles, adaptation types were studied. In addition, a comparative study was held on developing a generic model for adaptive educational/serious games, where selective models were compared with respect to specific concepts.

Considering our provided comparative analysis, the types of adaptation and disorders/disabilities supported in each model are highly dependable on the structure of that model. The model components, together with their description, functionality, and workflow sequence, collectively fluctuate the types of adaptation and disorders/disabilities that can be supported within the system. Moreover, the main entities interacting with the system have a similar effect on the system's level of automation. Thus, the depth of their role/interaction contributes in defining the feedback and evaluation mechanism, as well as the adaptation approach.

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