Technium
Education and Humanities

Technium Education and Humanities
Vol. 2, No. 2 pp.33-46 (2022)
ISSN: 2821-5079
www.techniumscience.com

A Strategy Game Using Adaptive Agents and Reinforcement Learning

Nikolaos Doukas[1], Nikolaos Bardis[1], Athanasios Drigas[2]

[1] Hellenic Army Academy, Department of Mathematics and Engineering Science, Vari - 16673, Greece
[2] Net Media Lab Mind - Brain R&D IIT - N.C.S.R. "Demokritos" , Athens, Greece

Abstract. This paper presents the functional specifications of a training platform for use in the training of cadets and serving officers. The game aims to teach trainees that their decisions need to be based both on strategic goals as well as on constraints imposed by international law concerning rules of engagement, ethical codes of conduct or environmental issues. Existing techniques bearing similarities to the required solution are presented. The importance of the problem is hence demonstrated and the possibilities for enhancing the quality of the learning experience for both students and instructors are explored. The rules of a computer game suitable for the cadets training are presented. The game is shown to be sufficient for use in the teaching of strategy ethics. The study leads to high level specifications for the design of the proposed training game. The functional design of the proposed game is then explained and its rules are listed. The design of adaptive software agents that are capable of assuming the role of non-player characters is presented. Further research work necessary for the development of optimization algorithms necessary for the design is described.

Keywords: Technology enhanced learning, teaching games, winning strategies, computer simulations, pursuit and evasion, differential games, reinforced learning.

1 Introduction

Learning games have been shown to be an important aid to the learning process, based on physiological, psychological and purely social reasons [1]. The initial reasoning for introducing game playing in the teaching process in higher education was the attractiveness of this particular class of learning objects. Current technological advances and trends may further enhance the motivation that learning games represent for higher education students, by adapting their level of difficulty and their responsiveness to the characteristics of the player [2].

Computer based learning games are a well accepted practice in the training of prospective and serving Armed Forces officers [3]. However, the process of military decision making is not a one – dimensional task and different aspects such as legal limitations, environmental considerations or strategy ethics need to be taken into account [4]. The application of computer assisted learning for the purpose of training cadets in the complexity of the decision making process requires the development of suitable models for the quantification of the quality and effectiveness of a particular decision in response to a particular situation at a specific time. This paper is concerned with the design of a learning platform that uses agents and reinforcement learning. Suitable mathematical models are proposed to support this platform. More specifically, a set of suitable rules is proposed that effectively models the requirements of a strategy game. The proposed strategy game exposes the trainee cadets to multiple parameter evaluation criteria. Strategy games have attracted research attention as a teaching tool for cadets, even using delivery on paper and in – classroom role playing [5]. A multidimensional assessment scheme for strategy games was proposed and analyzed in [5]. In the context of the same study, a baseline sample scenario and preliminary design principles for such a game have been listed.

The aim of this paper is to present a high level design specification of an interactive, on-line, multiplayer game that will be capable of supporting the training prospective officers of the armed forces in multiple disciplines. The game will focus on challenging the ability of the cadets to take decisions that take into account multiple conflicting requirements that arise from international law. The design is presented based on the paradigm of the strategy Ethics and Philosophy course. The game incorporates tactical and strategic aspects so as to enable students to appreciate the difficulties of abiding by ethical rules while achieving their military goals and devise methods for overcoming such difficulties. The design of the game allows users to compose new crisis scenarios, to determine the rules that are applicable in each case, to assign the importance of the different aspects of the game to the final scoring of the participants and of course to play the game. Algorithms developed in the context of the game can also be used as driving forces for decision support tools. Software agents are used that assume the part of non player characters and render the game more attractive as a learning tool for students. The agents use the concepts of reinforcement learning.

In Section 2, existing work on the field of games design for teaching and training purposes for both military and civilian contexts is presented. In Section 3, the functional specifications for the present work are explained and the high level functional design for the proposed strategy game is given. In Section 4, basic principles of reinforcement learning are presented. In Section 5 the design of software agents capable of participating in the proposed game is presented. In Section 6, the advantages of the proposed design are outlined. It is hence demonstrated that this design offers significant flexibility for instructors and effectively supports the teaching of the required topics of the curriculum. Finally, a plan for the implementation of the game and its assessment in real teaching is given.

2 Interactive games for training in decision making

The use of games for teaching specialized skills to prospective or serving officers of the armed forces is a well accepted approach ([3], [4], [5], [6], [9], [10], [11]). Officers, as well as many other professionals, need to be able of taking accurate decisions within very strict time limits while taking into account a large amount of possibly uncertain information. This is a very complex task and it is hence difficult to train the personnel simply on a theoretical basis. Such decisions involve subjective evaluation criteria, constraints of a physical or legal nature, assessment of imprecise data and selection from multiple action alternatives. For the case of military operations, the situation the officer has to be trained in is called the “Fog of War” [4], a term that illustrates the fact that the commanding officer always has an impaired view of the complete picture of the field of action.

The use of computer simulations for training (or aiding) personnel to efficiently cope with this kind of situations is always impeded by the fact that both the decision space of such problems, as well as the parameter space upon which these decisions are based are neither finite, nor can they be unambiguously defined [3]. What is proposed in literature therefore is the use of mathematical optimization to follow the situation as it evolves in real time or pseudo-real time ([3], [8], [11], [13]).

Depending on the training required, different types of mathematical modeling may be employed. Pursuit and Evasion situations may be considered as an example of a Differential Game [8]. Pursuit and Evasion games include the “Guarding the target problem, deadline games and patrolling games [8]. Their general aim is to guard a target, which is an area on the plane, from the attacks launched by the evader. Such problems may be formulated in both continuous and discrete versions. A discrete guarding game played by two players based on a directed or undirected graph is an NP hard problem [8]. When considered under restrictions, such as a limited size plane, encompassing an undirected graph, analytical answers as to the optimal strategy that a player should follow may be derived [9]. In its simpler form, a pursuit game is a zero-sum game, in that the goals of the players are conflicting (player A wants to occupy space S, currently occupied by B etc). A less simplistic approach to the design of pursuit games is the non-zero sum case where the goals of the players may not always be conflicting [14].

For a three player discrete game where coalitions are possible, probabilistic analysis, rather than the adoption of an optimal analysis is proposed [10]. Allowing explicit coalitions in games completely alters the theoretical perspective of the game, since the actions of the allied players are independent and may encompass different field information. Defeating a coalition may involve different strategies, such as defeating each ally at different times [10].

A further distinction needs to be made between full information and partial information games. In full information games, all players have full knowledge of all the opponent's forces, as well as all their past moves. In partial information games, players lack knowledge of their opponent's past moves and their opponent's present situation. A player must hence hypothesize about all these parameters and the complexity of the analysis required to derive an optimal solution increases dramatically [11]. Partial information games are better suited to model the fog of strategy concept.

Continuous modeling of pursuit situations is also possible. In this case pursuers and targets are moving in continuous space and time and the requirements are minimizations of the distances and times subject to the physical constraints of the hardware being used [12]. The scope of the game in this case becomes an optimization of the speed of reaction of the players and deviates from the aim of this work which is targeted to the philosophical aspects of applying the ethics of strategy rules, subject to the strategic and tactical aims, as well as to the limitations of the fog of strategy. Recent technological advances have made it feasible for the delivery of the educational content to acquire even more attractive realizations, such as mobile platforms (e.g. [1], [2]). Furthermore, it has become possible for instructors of non- technical subjects to get actively involved in the design of their own games using tools such as Scratch [15], Script Ease [19] and Kodu [20].

Computer based learning environments are evolving into an indispensable tool for catching the attention of the Internet generation of tertiary education students and this is shown by the research active in this field [13]. Several technological topics were presented that relate to the implementation and deployment of such games. The design of the game that satisfies the requirements for the training armed forces cadets is presented.

3 Design of the game

The aim of this work was to design a strategy game that would be suitable for delivery over a computer based learning platform and that would challenge, enhance and test the cadets' abilities in producing strategically correct decisions under restrictions. The paradigm adopted in the design of the prototype game, was that of the strategy ethics and international conflict law and its effect on the outcome of a conflict concerning tactical forces, terrorist groups and civilian population. Given that this game was targeted for application in the case of prospective Armed Forces officers, it needed to be able to keep the students – players constantly aware of the inevitable impairment of the fog of strategy. It is proposed to be a partial information game of more than two players with the possibility of coalitions.

3.1 The concept of the game

More specifically the proposed game is based on a grid, similar in concept with a naval battle game [4] or chess. The main difference from these games is that the proposed strategy game uses a larger grid with significantly finer resolution. The players of the game belong to one of two groups:

- Tactical army: These are players that represent the armed forces of a state and are hence bound by laws, ethical rules etc.
- Terrorist groups: These players represent forces that are not bound by ethics or rules and their behavior is totally unpredictable. Such players may be human participants or may be automatically handled by the computer program.

In addition to the above, there are two additional categories of non-player characters that may be active on the board or be implicitly represented:

- Strategic command: Represent the leaders of tactical armies and set military targets and assessment parameters
- Civilian population: Represent non-fighting individuals that exist on parts of the grid. Despite the fact that they are not active militarily, they may influence the outcome of a battle in various ways, e.g by storing weapons for one player or preventing a player from attacking a specific target.

The two last player categories could typically be game parameters set by the instructor (implicit participation) or are non-player characters (agents) that are managed by the computer system. Two or more players may belong to an alliance.

Each player possesses a number of pawns that are placed on specific positions on the grid. The grid is a discrete space, i.e. pawns may reside only on the vertices of the grid. Areas on the grid represent different geographical areas (ground, sea, buildings, difficult to access areas). Each pawn represents a specific type of forces (infantry, armored vehicles, ships, planes etc). The pawns may be laid on the grid by either the instructor or the player at the beginning of the game. Civilian pawns are also positioned on the grid by the instructor.

Each player plays on their own computer screen. On their own screen they are capable of seeing their own pawns and the pawns of their allies. Each of the pawns of a player also conveys intelligence information to their headquarters. In practice, this means that a player can also observe on their screen information about their opponents' pawns that their own pawns can see. An infantry unit will hence give its owner visibility over a small area around it, while an airplane will give visibility over a larger area.

3.2 Playing the game

Each player plays in turn and moves a number of pawns or uses a number of weapons. Each pawn may move a certain distance on the grid according to its type. The number of pawns moved at each turn by each player is a parameter set by the instructor. Each pawn carries a limited number of weapons, depending on its type. Each weapon is effective against specific types of adversary pawns. A player may choose to either destroy or arrest pawns that are in range of their weapons. The use of certain types of weapons may be prohibited or impossible in certain areas. Weapons may be stored in certain positions on the grid. Such weapons are accessible to anybody occupying that part of the grid. For simplicity, weapons are classified in two categories – long range and short range weapons (quoted in literature as range attack and melee attack weapons [16]).

3.3 Pawn movement limitations

A player is given an initial amount of credit at the beginning of the game. Each pawn move has a cost that is deducted from their credit. Similarly, each weapon use also has a cost. A player may not move a pawn or use a weapon if they do not have enough credit left for this move. Certain positions on the grid are not allowed for certain types of pawns (e.g. the sea for infantry).

3.4 Definition of the mission

Players are assigned missions that they need to achieve. A mission may involve occupying an area on the grid, arresting a number of adversary pawns, destroying a number of adversary pawns etc. Pawns that have been arrested and are prisoners of a player, incur a steady cost upon that player.

3.5 Scores and eviction of players from the game

Each part of a mission that is achieved carries a certain number of points towards the final assessment of the player. A player also adds points to their score according to the credit they have left at the end of the game. A player loses points by not having achieved certain parts of their mission at the end of the game, by destroying civilians or allies and by using certain weapons in certain areas. These weapon – area limitations are instructor set parameters.

A player is evicted from the game if certain weapons in certain areas, if they use a weapon on an area with no targets or if they disobey any other instructor set rules. The player is also evicted from the game if a certain percentage of their pawn is destroyed or captured. The game finishes when a player achieves a certain percentage of the goals of their mission or if there is only one player left in the game.

For the case when some players assume the role of terrorists, scoring becomes asymmetrical, i.e. some players may score points for the same actions that cost points to other players.

4 The Reinforcement Learning Principle

The reinforcement learning principle is an artificial intelligence concept that attempts to partially model the learning process as a result of the interaction of the individual with their environment [20]. Within the concept of this study, reinforcement learning has nothing to do with the learning process concerning the human participants (cadets). The research goal was to increase the challenge level that the computer game represented for the students. This goal was pursued by the inclusion in the design of automated adaptive agents that are able to learn from the individual players and dynamically adjust the level of difficulty of the game to the level of expertise of these players. These artificial intelligence entities are therefore the virtual opponents that make the game interesting for its player.

Conceptually [20], the agent may be considered to be continuously interacting with the environment. The agent selects certain actions and the environment produces response to those actions by presenting new situations to the agent. Additionally, the environment offers a reward in response to the move of the agent. These rewards that for the case of the computer games take the form of numerical values are the driving force of the agent's future moves, since the agent essentially aims to maximize the overall amount of reward collected over time. The situations that the agent is faced with, assume the role of the state of the environment (or the system). The state used needs to be chosen such that it retains all information about the past history of the environment. If this condition is met, the state variables are said to possess the Markov property and the relevant task is called a Markov Decision Process (MDP) [16], [20]. When the state and action spaces are finite, then the task is a finite MDP. The concept of the MDP will not be analyzed here, as it is beyond the scope of this study. Further information may be found in [16] and [20]. What needs to be clear though is the implication of the Markovian property for the state; given a state of the system, the probability that any other state will be the next state can be calculated without any extra information. More specifically, if the current state is s and the action taken is a then for each possible next state s' [20]:

$$P^a_{ss'} = \Pr\{s_{t+1} = s' | s_t = s, a_t = a\} \quad (1)$$

Technium
Education and Humanities

Technium Education and Humanities
Vol. 2, No. 2 pp.33-46 (2022)
ISSN: 2821-5079
www.techniumscience.com

and the expected value of the next reward is:

$$R^{a}_{ss'} = E\{r_{t+1} \mid s_t = s, a_t = a, s_{t+1} = s'\} \tag{2}$$

A policy π of the agent can then be described mathematically as a mapping from the set of all states and the set of all actions to the probability

$$\pi(s, a) \tag{3}$$

of observing state s and action a.

Next, the value of observing a policy from time t onwards may be calculated as:

$$V^{\pi}(s) = E_{\pi}\{R_t \mid s_t = s\} = E_{\pi}\{\sum_{k=0}^{\infty}\gamma^{k} r_{t+k+1} \mid s_t = s\} \tag{4}$$

where γ is the discount factor, a value weighing what a reward in the future is worth now. The value of choosing action a while in state s under policy π is calculated as:

$$Q^{\pi}(s, a) = E_{\pi}\{R_t \mid s_t = s, a_t = a\} = E\{\sum_{k=0}^{\infty}\gamma^{k} r_{t+k+1} \mid s_t = s, a_t = a\} \tag{5}$$

A real system needs therefore to maintain a table of the values of Q for all s and a. In order to allow the system to explore new paths, small deviations from a policy may be allowed, as proposed in [17]. An agent will therefore choose the action with the maximum Q value with probability (1 – ε) and a random action with probability ε. The study in [17] proposes therefore the following algorithm (Retaliate) for updating the Q table:

```
Algorithm Retaliate
If rand() > ε
   Take action a s.t. Q(s,a) is maximum for current s
Else
   Take random action a (applicable to s)
s'= result_of(a)
Reward = V(s') - V(s)
Update Q
```

5 Reinforcement Learning for the strategy Game

The previous section presented fundamental results concerning the reinforcement learning principle. The aim of this section will be to present the assumptions and modifications that are necessary for a reinforcement learning based software agent to efficiently operate within in the framework of the game designed.

Reinforcement learning has been presented applied to a variety of paradigms of game terrains. The terrain that is most applicable to the strategy game case is the rectangular grid example presented in [20]. Within this model, the state of the agent is the vertex of the grid the agent is on. Similarly, the state value function (Q-table) is zero for any vertex other than the target vertex.

As it was already mentioned in a previous section, the world of the game is represented as a rectangular grid. Within this grid, it is straightforward to define the mission as a particular vertex (or group of vertices) where the agent needs to land. However, the calculation of the Q table becomes slightly more involved. As explained in the rules of the game in a previous section, a player (or an agent) does not have a clear perception of the state of their opponent's forces. Additionally, the table Q of movement values is time-varying, as movements of the player forces, rearrange the values that moves have at various positions. Furthermore, there exist moves that cause the player to be expelled from the game and carry therefore a value of -□. For this reason, the following modification in the update of the Q values is proposed.

Technium Education and Humanities
Vol. 2, No. 2 pp.33-46 (2022)
ISSN: 2821-5079
www.techniumscience.com

The Q table holds information about the value of a move based on the distance from the target and the known enemy forces. At every move, the agent updates the Q value for any action that they consider with information about other factors (e.g. the legitimacy of the move). Hence the following adaptation algorithm may be used:

```
Algorithm GameAgent
If (s is a policy case)
 choose fixed a
Else if rand() > ε
 choose action a s.t. Q(s,a) is maximum for current s
Else
 choose random action a (applicable to s)
While (a is illegal) OR (no credit for a)
 choose other random action a (applicable to s)
 s'= result_of(a)
 Reward = V(s') - V(s)
 Update Q
```

Furthermore, the values of γ and ε will need to be determined so as to reflect the new needs of the algorithm. Since the situation on the board changes rapidly and is based on limited data sets, the chosen value of γ needs to be small, signifying that future rewards are not worth very much (since things may have changed by then). The constant ε on the other hand needs to be relatively large, so as to allow the agent o wonder around the board and seek for the correct move.

6 Assessment of the design and future work

The design of the game that was presented in a previous section represents a realistic model for the situations in which the players will have to operate and make decisions. All the necessary rules have been stated that will encourage the players to base their decisions on the required factors (both strategic and others). The ethical aspect of the game has been expressed as rules that either cost a player points or cause the "sudden death" of a player, i.e. their immediate expulsion from the game. This way, ethical rules could be measured on the same scale as other objectives of the game such as the completion of the player's mission or the credit points that the player has had to spend in order to pursue their mission. This model represents a real world situation where deviation from the ethical rules incurs costs upon real world players in the form of social pressure, social exclusion as well as legal proceedings.

The proposed design gives extensive liberty to the instructor to implement the game so as to match the priorities of their own classroom teaching, the particular aspects of the theory that they wish to stress or the strengths and weaknesses of a particular group of students. The instructor also has full liberty to participate in the game by assuming unconventional roles, such as that of a terrorist group, groups of civilians or the strategic leader of the players. The design also allows the game to change its scope, from a training exercise to a decision support platform. This is feasible by the use of suitable optimization algorithms that derive feasible, optimal or suboptimal sequences of movements for completing missions, based on mathematical analysis or heuristic rules.

Automated adaptive software agents may assume any role in the game, making the learning experience both more exciting and more efficient as a teaching tool. The introduction of the agents makes the entire concept of the game more flexible and more scalable than it would have been otherwise.

There are still several theoretical and practical issues regarding this work that need to be studied. These have to do with the design of algorithms that reach optimal or near optimal solutions for specific situations with which the players may be faced. These algorithms will have to be designed based on both analytical and heuristic approaches. The feasibility of seeking an optimal solution will have to be studied. Additionally, the calculation of limits in performance may be sought that can be used to compare the relative merits of heuristic solutions. The calculations of lower bounds that permit the determination of realistic tactical and strategic goals are also of interest to this work. Such a lower bound is derived in [8] for the case of a Cop and Robber game, where it is shown that depending on the distance between the two players, the game may be futile for either the Cop or the Robber.

As far as the algorithm for the control of the software agents is concerned, variable rate updates for the estimation of the reward function need to be further investigated. This is required since in the case proposed educational game platform the rate at which the reward function changes is larger than any of the examples shown in literature ([16], [17], [20]). Additionally, due to the nature of the game the error of the reward function estimation is significantly larger than for any other of documented example. Modifications to the algorithm may be sought that would allow the software agents to form coalitions against the players (trainees). A coalition of an agent with a player would also be interesting.

The final and maybe most important step of this study will be the use of the game in the classroom and the assessment of its impact towards facilitating the teaching and improving the students' understanding of the topic. Additional interest is focused on the effectiveness of the strategies that the optimization algorithms will produce for the non player characters that are controlled by agents.

7 Conclusions

The exploitation of digital technologies in education domain is very productive and successful, facilitates and improves the educational procedures via Mobiles [25-34], various ICTs applications [35-67], AI & STEM [68-79], and games [80-85]. Additionally the combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [86-123] as well as with environmental factors and nutrition [21-24], accelerates and improves more over the educational practices and results.

Moreover this presentation concentrated on the use of computer based learning platforms implementing strategy games for the purpose of training armed forces cadets. The aim of these strategy games was to enable the students to practice taking decisions that take into consideration not only their strategic and tactical goals, but also satisfying other constraints such as requirements set by international law (regarding e.g. rules of engagement, international treaties, environmental laws). A bibliographical study was presented that demonstrated the importance of the problem, as well as the fact that there exist significant technological opportunities to enhance the learning experience for both students and instructors. The high level design of a training game was presented that is suitable for use in the teaching of strategy ethics to students. The game was designed to be able to assess the player skills in maintaining ethical rules and international laws on armed conflict while still achieving the strategic and tactical aims of their missions. The rules of the game were presented. The design was shown to offer flexibility to the instructors, allowing them to adapt the game to the requirements of their own teaching. A study was presented for the introduction of automated adaptive agents in the game that play the part of the enemy (terrorist) forces during the simulation. The use of the agents serves the purpose of enhancing the user learning experience. Directions for further development of the game were presented, in both theoretical and applied aspects.

8 References

[1] Minović, M., Štavljanin, V., Milovanović, M., Starčević, D.: Adventure Game Learning Platform. International Journal of Knowledge Society Research, 1(1), 13-22, January-March (2010)

[2] Torrente, J., Moreno-Ger, P., Fernandez-Manjon, B.: Learning Models for the Integration of Adaptive Educational Games in Virtual Learning Environments. Z. Pan et al. (Eds.), Edutainment 2008, LNCS 5093, pp. 463–474, (2008)

[3] Hicks, J., Petrov, V., Stoyen, A., Zhu, Q.: Intelligent agent-based software architecture for combat performance under overwhelming information inflow and uncertainty. Seventh IEEE International Conference on Engineering of Complex Computer Systems, 200-210. (2001)

[4] Lekea, I.: New Technologies, Distance Learning, Internet and Games; their contribution in a New Approach to the Educational practice. The Case Study of the Philosophy Course in the Hellenic Army Academy. 1st Hellenic Conference of Educational Sciences, Athens, (2009)

[5] Lekea, I and Sotiriadis, P.: Designing an Educational Game for Aircraft Engineers; Theoretical Experience and Effectiveness in Teaching Practice. 1st Hellenic Conference of Educational Sciences, Athens, (2009)

[6] Andreatos, A. and Lekea I.: Technological Evolution and Pedagogical Reapproach to Effective Learning Using Games within the Hellenic Air Force Academy. The Case Study of the Philosophy Course in the Hellenic Army Academy. Readings in Technology and Education: Proceedings of ICICTE, 799 – 811 (2009)

[7] Naval battle on-line game: http://www.energynet.net/games/battle/

[8] Fomin, F., Golovach, P. et al.: How to Guard a Graph? Technical Report Nr. 605, Department of Computer Science, ETH Zurich. (2008)

[9] Alonso, L. and Reingold, E.: Lower bounds for Cops and Robbers Pursuit. http://emr.cs.uiuc.edu/~reingold/copsandrobber.pdf (2008)

[10] Dshalalow, J. and Treerattrakoon, A.: Set-Theoretic Inequalities in Stochastic Noncooperative Games with Coalition. Journal of Inequalities and Applications Article ID 713642 (2008)

[11] Hespanh, J., Ateskan, Y. and Kizilocak, H.: Deception in Non-Cooperative Games with Partial Information. Proc. of the 2nd DARPA-JFACC Symposium on Advances in Enterprise Control, pp 1 – 9. (2000)

[12] Looker, J.: Minimum Paths to Interception of a Moving Target when Constrained by Turning Radius. Publication DSTO–TR–2227, Defence Science and Technology Organization, Air Operations Division, Australian Dept of Defense. (2008)

[13] Fraenkel, A.: Combinatorial Games: Selected Bibliography with a Succinct Gourmet Introduction. The Electronic Journal of Combinatorics. (2009)

[14] Kwon, O. and Tarashnina, S.: On a Time-Consistent Solution of a Cooperative Differential Time-Optimal Pursuit Game. J. Korean Math. Soc. 39, No. 5, pp. 745–764. (2002)

[15] Maloney, J., Peppler, K, Kafai, Y, Resnick, M. and Rusk, N: Programming by choice: Urban Youth Learning Programming with Scratch. ACM SIGCSE ’08, pp. 367–371. (2008)

[16] Cutumisu, M., Szafron, D., Bowling M. and Sutton, R.: Agent Learning using Action Dependent Learning Rates in Computer Role-Playing Games.Proc of the Fourth Artificial Intelligence and Interactive Digital Entertainment Conference. (2008)

[17] Auslander, B., Lee-Urban, S., Hogg, C. and Muñoz-Avila, H.: Recognizing the Enemy: Combining Reinforcement Learning with Strategy Selection using Case-Based Reasoning Lecture Notes in Computer Science, Vol. 5293, pp. 59–73. (2008)

[18] Sutton, R. and Barto A.:Reinforcement Learning: An Introduction. MIT Press (1998)

[19] Script Ease home page: http://webdocs.cs.ualberta.ca/~script/index.html

[20] Kodu home page: http://www.kodu.com

[21] Stavridou Th., Driga, A.M., Drigas, A.S., Blood Markers in Detection of Autism ,International Journal of Recent Contributions from Engineering Science & IT (iJES) 9(2):79-86. 2021.

[22] Zavitsanou, A., & Drigas, A. (2021). Nutrition in mental and physical health. Technium Soc. Sci. J., 23, 67.

[23] Driga, A.M., Drigas, A.S. “Climate Change 101: How Everyday Activities Contribute to the Ever-Growing Issue”, International Journal of Recent Contributions from Engineering, Science & IT, vol. 7(1), pp. 22-31, 2019. https://doi.org/10.3991/ijes.v7i1.10031

[24] Driga, A.M., and Drigas, A.S. "ADHD in the Early Years: Pre-Natal and Early Causes and Alternative Ways of Dealing." International Journal of Online and Biomedical Engineering (IJOE), vol. 15, no. 13, 2019, p. 95., doi:10.3991/ijoe.v15i13.11203

[25] Vlachou J. and Drigas, A. S., "Mobile technology for students and adults with Autistic Spectrum Disorders (ASD)," International Journal of Interactive Mobile Technologies, vol. 11(1), pp. 4-17, 2017

[26] Papoutsi C., Drigas, A. S., and C. Skianis, "Mobile Applications to Improve Emotional Intelligence in Autism – A Review," Int. J. Interact. Mob. Technol. (iJIM); Vol 12, No 6, 2018

[27] Karabatzaki, Z., Stathopoulou, A., Kokkalia, G., Dimitriou, E., Loukeri, P., Economou A., & Drigas, A. (2018). Mobile Application Tools for Students in Secondary Education. An Evaluation Study. International Journal of Interactive Mobile Technologies (iJIM), 12(2), 142-161

[28] Drigas, A. S., and Angelidakis P., 'Mobile Applications within Education: An Overview of Application Paradigms in Specific Categories', International Journal of Interactive Mobile Technologies (iJIM), vol. 11, no. 4, p. 17, May 2017. https://doi.org/10.3991/ijim.v11i4. 6589

[29] Stathopoulou A., Loukeris D., Karabatzaki Z., Politi E., Salapata Y., and Drigas, A. S., "Evaluation of Mobile Apps Effectiveness in Children with Autism Social Training via Digital Social Stories," Int. J. Interact. Mob. Technol. (iJIM); Vol 14, No 03, 2020

[30] Stathopoulou, et all Mobile assessment procedures for mental health and literacy skills in education. International Journal of Interactive Mobile Technologies, 12(3), 21-37, 2018,

[31] Drigas, A., Kokkalia, G. & Lytras, M. D. (2015). Mobile and Multimedia Learning in Preschool Education. J. Mobile Multimedia, 11(1/2), 119–133.

[32] Stathopoulou, A., Karabatzaki, Z., Kokkalia, G., Dimitriou, E., Loukeri, P.I., Economou, A., and Drigas, A. (2018). Mobile assessment procedures for mental health and literacy skills in education. International Journal of Interactive Mobile Technologies (iJIM), 12(3):21-37. https://doi.org/10.3991/ijim.v12i3.8038

[33] Drigas, A.S., Ioannidou, R.E., Kokkalia, G. and Lytras, M. (2014), "ICTs, mobile learning and social media to enhance learning for attention difficulties", Journal of Universal Computer Science, Vol. 20 No. 10, pp. 1499-1510.

[34] Kokkalia G. K. and Drigas, A. S., "Mobile learning for special preschool education," International Journal of Interactive Mobile Technologies, vol. 10 (1), pp. 60-67, 2016

[35] Pappas, M.A.; Papoutsi, C.; Drigas, A.S. Policies, Practices, and Attitudes toward Inclusive Education: The Case of Greece. Soc. Sci. 2018, 7, 90.

[36] Drigas, A. S., & Ioannidou, R. E. (2011, September). ICTs in special education: A review. In World Summit on Knowledge Society (pp. 357-364). Springer, Berlin, Heidelberg.

[37] Drigas, A. S., J.Vrettaros, L.Stavrou, D.Kouremenos, E-learning Environment for Deaf people in the E-Commerce and New Technologies Sector, WSEAS Transactions on Information Science and Applications, Issue 5, Volume 1, November 2004.

[38] Drigas, A.S., Vrettaros, J. and Kouremenos, D. (2004a) 'Teleeducation and e-learning services for teaching English as a second language to deaf people, whose first language is the sign language', WSEAS Transactions on Information Science and Applications, Vol. 1, No. 3, pp.834–842.

[39] Drigas, A., Koukianakis, L., Papagerasimou, Y., Towards an ICT-based psychology: Epsychology, Computers in Human Behavior, 2011, 27:1416–1423. https://doi.org/10.1016/j.chb.2010.07.045

[40] Charami, F., & Drigas, A. (2014). ICTs in English Learning and Teaching. International Journal of Engineering and Science. Vol. 2(4):4-10. DOI: 10.3991/ijes.v2i4.4016

[41] Drigas A.S., Kouremenos D (2005) An e-learning system for the deaf people. In: WSEAS transaction on advances in engineering education, vol 2, issue 1, pp 20–24

[42] Drigas A., Pappas M, and Lytras M., "Emerging technologies for ict based education for dyscalculia: Implications for computer engineering education," International Journal of Engineering Education, vol. 32, no. 4, pp. 1604–1610, 2016.

[43] Drigas, A. & Kokkalia, G. 2017. ICTs and Special Education in Kindergarten. International Journal of Emerging Technologies in Learning 9 (4), 35–42.

[44] Drigas A., and Koukianakis L., A Modular Environment for E-learning and E-psychology Applications, WSEAS Transactions on Information Science and Application, Vol. 3, 2004, pp. 2062-2067.

[45] Drigas, A., Leliopoulos, P.: Business to consumer (B2C) e-commerce decade evolution. Int. J. Knowl. Soc. Res. (IJKSR) 4(4), 1–10 (2013)

[46] Pappas M, Drigas A, Papagerasimou Y, Dimitriou H, Katsanou N, Papakonstantinou S, et al. Female Entrepreneurship and Employability in the Digital Era: The Case of Greece. Journal of Open Innovation: Technology, Market, and Complexity. 2018; 4(2): 1.

[47] Papanastasiou G., Drigas, A. S., Skianis Ch., M. Lytras & E. Papanastasiou, "Patient-Centric ICTs based Healthcare for students with learning, physical and/or sensory disabilities," Telemat Inform, vol. 35, no. 4, pp. 654–664, 2018. https://doi. org/10.1016/j.tele.2017.09.002

[48] Drigas, A., & Kontopoulou, M. T. L. (2016). ICTs based Physics Learning. International Journal of Engineering Pedagogy (iJEP), 6(3), 53-59. https://doi.org/10.3991/ijep.v6i3. 5899

[49] Papanastasiou, G., Drigas, A., Skianis, C., and Lytras, M. (2020). Brain computer interface based applications for training and rehabilitation of students with neurodevelopmental disorders. A literature review. Heliyon 6:e04250. doi: 10.1016/j.heliyon.2020.e04250

[50] Drigas, A. S., John Vrettaros, and Dimitris Kouremenos, 2005. "An e-learning management system for the deaf people," AIKED '05: Proceedings of the Fourth WSEAS International Conference on Artificial Intelligence, Knowledge Engineering Data Bases, article number 28.

[51] Pappas, M., Demertzi, E., Papagerasimou, Y., Koukianakis, L., Kouremenos, D., Loukidis, I. and Drigas, A. 2018. E-Learning for deaf adults from a user-centered perspective. Education Sciences 8(206): 3-15.

[52] Marios A. Pappas, Eleftheria Demertzi, Yannis Papagerasimou, Lefteris Koukianakis, Nikitas Voukelatos, and Drigas, A. S., 2019. Cognitive Based E-Learning Design for Older Adults. Social Sciences 8, 1 (Jan. 2019), 6. https://doi.org/10.3390/socsci801000

[53] Drigas, A. S., Leyteris Koukianakis: Government online: An e-government platform to improve public administration operations and services delivery to the citizen. WSKS (1), volume 5736 de Lecture Notes in Computer Science, 523–532. Springer, 2009.

[54] Theodorou, P.; Drigas, A. ICTs and Music in Generic Learning Disabilities. Int. J. Emerg. Technol. Learn. 2017, 12, 101–110

[55] Drigas, A., Kokkalia, G., & Lytras, M. D. (2015). ICT and collaborative co-learning in preschool children who face memory difficulties. Computers in Human Behavior, 51, 645–651. https://doi.org/10.1016/j.chb.2015.01.019

[56] Pappas, M.A., & Drigas, A.S. (2015). ICT based screening tools and etiology of dyscalculia. International Journal of Engineering Pedagogy, 3, 61-66.

[57] Drigas, A., & Kostas, I. (2014). On Line and other ICTs Applications for teaching math in Special Education. International Journal of Recent Contributions from Engineering, Science & IT (iJES), 2(4), pp-46. http://dx.doi.org/10.3991/ijes.v2i4.4204

[58] Alexopoulou, A, Batsou, A, Drigas, A. (2019). Resilience and academic underachievement in gifted students: causes, consequences and strategic methods of prevention and intervention. International Journal of Online and Biomedical Engineering (iJOE), vol. 15, no. 14, pp. 78.

[59] Pappas, M. A., & Drigas, A. S. (2015). ICT Based Screening Tools and Etiology of Dyscalculia. International Journal of Engineering Pedagogy, 5(3)

[60] Drigas, A. & Ioannidou, R. E. (2013). Special education and ICT's. International Journal of Emerging Technologies in Learning 8(2), 41– 47.

[61] Drigas, A., & Papanastasiou, G. (2014). Interactive White Boards in Preschool and Primary Education. International Journal of Online and Biomedical Engineering (iJOE), 10(4), 46–51. https://doi.org/10.3991/ijoe.v10i4.3754

[62] Drigas, A. S. and Politi-Georgousi, S. (2019). Icts as a distinct detection approach for dyslexia screening: A contemporary view. International Journal of Online and Biomedical Engineering (iJOE), 15(13):46–60.

[63] Lizeta N. Bakola, Nikolaos D. Rizos, Drigas, A. S., "ICTs for Emotional and Social Skills Development for Children with ADHD and ASD Co-existence"International Journal of Emerging Technologies in Learning (iJET), https://doi.org/10.3991/ijet.v14i05.9430

[64] Kontostavlou, E.Z., & Drigas, A.S. (2019). The Use of Information and Communications Technology (ICT) in Gifted Students. International Journal of Recent Contributions from Engineering, Science and IT, 7(2), 60-67. doi:10.3991/ijes.v7i2.10815
[65] Drigas, A. S., and Vlachou J. A., "Information and communication technologies (ICTs) and autistic spectrum disorders (ASD)," Int. J. Recent Contrib. Eng. Sci. IT (iJES), vol. 4, no. 1, p. 4, 2016. https://doi.org/10.3991/ijes.v4i1.5352
[66] Drigas, A. S., Koukianakis, L, Papagerasimou, Y. (2006) "An elearning environment for nontraditional students with sight disabilities.", Frontiers in Education Conference, 36th Annual. IEEE, p. 23-27.
[67] Drigas A., and Koukianakis L. An open distance learning e-system to support SMEs e-enterprising. In proceeding of 5th WSEAS Internationalconference on Artificial intelligence, knowledge engineering, data bases (AIKED 2006). Spain
[68] Kefalis C and Drigas A. (2019) Web Based and Online Applications in STEM Education. International Journal of Engineering Pedagogy (iJEP) 9, 4 (2019), 76–85.https://doi.org/10.3991/ijep.v9i4.10691
[69] Drigas, A. S., Rodi-Eleni Ioannidou, A Review on Artificial Intelligence in Special Education, Information Systems, Elearning, and Knowledge Management Research Communications in Computer and Information Science Volume 278, pp 385-391, 2013 http://dx.doi.org/10.1007/978-3-642-35879-1_46
[70] Drigas, A., Vrettaros, J.: An Intelligent Tool for Building e-Learning Contend-Material Using Natural Language in Digital Libraries. WSEAS Transactions on Information Science and Applications 5(1) (2004) 1197–1205
[71] Drigas, A.S., Vrettaros, J., Koukianakis, L.G. and Glentzes, J.G. (2005). A Virtual Lab and e-learning system for renewable energy sources. Int. Conf. on Educational Tech.
[72] Drigas AS, Argyri K, Vrettaros J (2009) Decade review (1999-2009): artificial intelligence techniques in student modeling. In: World Summit on Knowledge Society. Springer, pp 552–564
[73] Vrettaros, J., Tagoulis, A., Giannopoulou, N., & Drigas, A. (2009). An empirical study on the use of Web 2.0 by Greek adult instructors in educational procedures. World Summit on Knowledge System (WSKS), 49, 164-170. http://dx.doi.org/10.1007/978-3-642-04757-2_18
[74] Drigas, A., Dourou, A. (2013). A Review on ICTs, E-Learning and Artificial Intelligence for Dyslexic's Assistance. iJet, 8(4), 63-67.
[75] Drigas, A. S., Ioannidou,E.R., (2012), Artificial intelligence in special education: A decade review, International Journal of Engineering Education, vol. 28, no. 6.
[76] Drigas, A. S., and Leliopoulos, Panagiotis, The Use of Big Data in Education, International Journal of Computer Science Issues, Vol. 11, Issue 5, 2014, 58-63
[77] Anagnostopoulou, P., Alexandropoulou, V., Lorentzou, G., Lykothanasi, A., Ntaountaki, P., & Drigas, A. (2020). Artificial intelligence in autism assessment. International Journal of Emerging Technologies in Learning, 15(6), 95-107. https://doi.org/10.3991/ijet.v15i06.11231
[78] Pappas, M., & Drigas, A. (2016). Incorporation of artificial intelligence tutoring techniques in mathematics. International Journal of Engineering Pedagogy, 6(4), 12–16. https://doi.org/10.3991/ijep.v6i4.6063
[79] Chaidi E, Kefalis C, Papagerasimou Y, Drigas (2021) A Educational robotics in Primary Education. A case in Greece. Research, Society and Development 10 (9)
[80] Papanastasiou, G. P., Drigas, A. S., & Skianis, C. (2017). Serious games in preschool and primary education: Benefits and impacts on curriculum course syllabus. International Journal of Emerging Technologies in Learning, 12(1), 44–56. https://doi.org/10.3991/ijet.v12i01.6065
[81] Kokkalia, G., Drigas, A., Economou, A., Roussos, P., & Choli, S. (2017). The use of serious games in preschool education. International Journal of Emerging Technologies in Learning, 12(11), 15-27. https://doi.org/10.3991/ijet.v12i11.6991
[82] Drigas, A. S., and Pappas M.A. "On line and other Game-Based Learning for Mathematics." International Journal of Online Engineering (iJOE) 11.4, 62-67, 2015 https://doi.org/10.3991/ijoe.v11i4.4742
[83] Papanastasiou, G., Drigas, A., Skianis, C., & Lytras, M. D. (2017). Serious games in K-12 education: Benefits and impacts on students with attention, memory and developmental disabilities. Program, 51(4), 424-440. https://doi.org/10.1108/prog-02-2016-0020

[84] Drigas, A. S., & Kokkalia, G. K. (2014). ICTs in Kindergarten. International Journal of Emerging Technologies in Learning, 9(2). https://doi.org/10.3991/ijet.v9i2.3278
[85] Kokkalia, G., Drigas, A., & Economou, A. (2016). The role of games in special preschool education. International Journal of Emerging Technologies in Learning (iJET), 11(12), 30-35.
[86] Drigas, A., & Mitsea, E. (2020). The 8 Pillars of Metacognition. International Journal of Emerging Technologies in Learning (iJET), 15(21), 162-178. https://doi.org/10.3991/ijet.v15i21.14907
[87] Drigas, A., & Papoutsi, C. (2019). Emotional intelligence as an important asset for HR in organizations: Leaders and employees. International Journal of Advanced Corporate Learning, 12(1). https://doi.org/10.3991/ijac.v12i1.9637
[88] Drigas, A. S., and M. Pappas, "The Consciousness-Intelligence-Knowledge Pyramid: An 8x8 Layer Model," International Journal of Recent Contributions from Engineering, Science & IT (iJES), vol. 5, no.3, pp 14-25, 2017. https://doi.org/10.3991/ijes.v5i3.7680
[89] Mitsea, E., & Drigas, A. (2019). A journey into the metacognitive learning strategies. International Journal of Online & Biomedical Engineering, 15(14). https://doi.org/10.3991/ijoe.v15i14.11379
[90] Drigas A, Karyotaki M (2017) Attentional control and other executive functions. Int J Emerg Technol Learn iJET 12(03):219–233
[91] Drigas A, Karyotaki M 2014. Learning Tools and Application for Cognitive Improvement. International Journal of Engineering Pedagogy, 4(3): 71-77. From (Retrieved on 13 May 2016)
[92] Drigas, A., & Mitsea, E. (2021). 8 Pillars X 8 Layers Model of Metacognition: Educational Strategies, Exercises &Trainings. International Journal of Online & Biomedical Engineering, 17(8). https://doi.org/10.3991/ijoe.v17i08.23563
[93] Drigas A., Papoutsi C. (2020). The Need for Emotional Intelligence Training Education in Critical and Stressful Situations: The Case of COVID-19. Int. J. Recent Contrib. Eng. Sci. IT 8 (3), 20–35. 10.3991/ijes.v8i3.17235
[94] Drigas, A., & Mitsea, E. (2020). The Triangle of Spiritual Intelligence, Metacognition and Consciousness. International Journal of Recent Contributions from Engineering, Science & IT (iJES), 8(1), 4-23. https://doi.org/10.3991/ijes.v8i1.12503
[95] Kokkalia, G., Drigas, A. Economou, A., & Roussos, P. (2019). School readiness from kindergarten to primary school. Intern. J.l of Emerging Technologies in Learning, 14(11), 4-18.
[96] Drigas, A., & Mitsea, E. (2021). Metacognition, stress-relaxation balance & related hormones. International Journal of Recent Contributions from Engineering, Science & IT (iJES), 9(1), 4–16. https://doi.org/10.3991/ijes.v9i1.19623
[97] Pappas M, Drigas A. Computerized Training for Neuroplasticity and Cognitive Improvement. International Journal of Engineering Pedagogy. 2019;.(4):50-62
[98] Papoutsi, C. and Drigas, A. (2017) Empathy and Mobile Applications. International Journal of Interactive Mobile Technologies 11. 57. https://doi.org/10.3991/ijim.v11i3.6385
[99] Papoutsi, C. & Drigas, A. (2016). Games for Empathy for Social Impact. International Journal of Engineering Pedagogy 6(4), 36-40.
[100] Karyotaki, M., & Drigas, A. (2015). Online and other ICT Applications for Cognitive Training and Assessment. International Journal of Online and Biomedical Eng.. 11(2), 36-42.
[101] Papoutsi, C., Drigas, A., & Skianis, C. (2019). Emotional intelligence as an important asset for HR in organizations: Attitudes and working variables. International Journal of Advanced Corporate Learning, 12(2), 21–35. https://doi.org/10.3991/ijac.v12i2.9620
[102] Chaidi I. and Drigas, A. S., "Autism, Expression, and Understanding of Emotions: Literature Review," Int. J. Online Biomed. Eng., vol. 16, no. 02, pp. 94–111, 2020. https://doi.org/10.3991/ijoe.v16i02.11991
[103] Chaidi I., Drigas, A. C Karagiannidis Autistic people's family and emotional intelligence Technium Soc. Sci. J. 26, 194
[104] Drigas, A. S., & Karyotaki, M. (2019). A Layered Model of Human Consciousness. International Journal of Recent Contributions from Engineering, Science & IT (iJES), 7(3), 41- 50. https://doi.org/10.3991/ijes.v7i3.11117

[105] Drigas, A. S., Karyotaki, M., & Skianis, C. (2018). An Integrated Approach to Neuro-development, Neuroplasticity and Cognitive Improvement. International Journal of Recent Contributions from Engineering, Science & IT (iJES), 6(3), 4-18.
[106] Karyotaki M. and Drigas, A. S., “Latest trends in problem solving assessment,” International Journal of Recent contributions from Engineering, Science & IT (iJES), vol. 4, no. 2, 2016. [Online serial]. Available: https://online-journals.org/index.php/i-jes/article/view/5800/. [Accessed Aug. 21, 2019]. https://doi.org/10.3991/ijes.v4i2.5800
[107] Mitsea E., Drigas, A. S., andMantas P., “Soft Skills & Metacognition as Inclusion Amplifiers in the 21st Century,” Int. J. Online Biomed. Eng. IJOE, vol. 17, no. 04, Art. no. 04, Apr. 2021. https://doi.org/10.3991/ijoe.v17i04.20567
[108] Angelopoulou, E. Drigas, A. (2021). Working Memory, Attention and their Relationship: A theoretical Overview. Research. Society and Development,10(5), 1-8. https://doi.org/10.33448/rsd-v10i5.15288
[109] Tourimpampa, A., Drigas, A., Economou, A., & Roussos, P. (2018). Perception and text comprehension. It'sa matter of perception! International Journal of Emerging Technologies in Learning (iJET). Retrieved from https://online-journals.org/index.php/ijet/article/view/7909/5051
[110] E Mitsea, A Drigas, C Skianis 2022 Breathing, Attention & Consciousness in Sync: The role of Breathing Training, Metacognition & Virtual Reality Technium Social Sciences Journal 29, 79-97
[111] A Drigas, M Karyotaki Online and other ICT-based Assessment Tools for Problem-solving Skills International Journal of Emerging Technologies in Learning (Online) 11 (4), 56
[112] A Drigas, E Mitsea, C Skianis Intermittent Oxygen Fasting and Digital Technologies: from Antistress and Hormones Regulation to Wellbeing, Bliss and Higher Mental States BioChemMed 3 (2), 55-73
[113] A Sideraki, A Drigas Artificial Intelligence (AI) in Autism Technium Social Sciences Journal 26, 262-277
[114] E Mitsea, A Drigas, C Skianis Cutting-Edge Technologies in Breathwork for Learning Disabilities in Special Education Technium Social Sciences Journal 34, 136-157
[115] A Drigas, E Mitsea, C Skianis Subliminal Training Techniques for Cognitive, Emotional and Behavioural Balance. The role of Emerging Technologies Technium Social Sciences Journal 33, 164-186
[116] P Anagnostopoulou, A Drigas 2020 ICTs, Mindfulness and Emotional Intelligence in Inter-National Educational Policies. Int. J. Recent Contributions Eng. Sci. IT 8 (4), 48-60
[117] A Stathopoulou, M Liouni, Y Salapata, A Drigas 2022 Emotional difficulties and post-traumatic stress disorder symptoms in children refugees & the role of ICTs: A case study in northern Greece borders Technium Social Sciences Journal 31, 213-227
[118] C Gatsakou, N Bardis, A Drigas 2022 The Theatre of Mind: An educational tool of teaching Emotional Intelligence via ICTs and distant learning Technium Social Sciences Journal 31, 241-255
[119] V Galitskaya, A Drigas 2020 A Neurological View for Mathematical Learning Disabilities Neurology and Neurobiology 2 (4), 1-4
[120] Kefalis, A Drigas 2020 S.T.E.M.: Inquiry-Based Learning and Gifted Education Neurology and Neurobiology 3(4):2-5 3 (4), 2-5
[121] I Chaidi, C Papoutsi, A Drigas, C Skianis 2022 Women: E-Entrepreneurship and Emotional Intelligence Technium Social Sciences Journal 30, 214-237
[122] V Bravou, AM Driga, A Drigas 2022 Emotion Regulation, the Function of Stress Hormones & Digital Technologies BioChemMed 3 (2), 27-34
[123] C Papoutsi, I Chaidi, A Drigas, C Skianis, C Karagiannidis 2022 Emotional Intelligence & ICTs for Women and Equality Technium Social Sciences Journal 27, 253-268