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EXPERIENTIAL LEARNING ACTIVITY: TIC-TAC-TOE APPLICATION USING ROBOTICS

O. Trull-Dominguez[1], A. Peiró-Signes[2], J.A. Cabrero-Hernández[1], J. Rodríguez-Rico[1]

[1]IES Gonzalo Anaya (SPAIN)
[2]Universidad Politécnica de Valencia (SPAIN)

Abstract

This paper focuses on the results obtained by developing an experiential learning activity (ELA) using DOBOTs (learning robots based on Arduino cores). In contrast to traditional teaching-learning procedures, ELAs permits students to experience real-world applications and more fully internalise basic concepts. Using scaffolding strategies, this ELA allowed the students to learn about robot arm positioning, tolerancing while positioning, sensor positioning and hysteresis understanding. A TIC-TAC-TOE game is an easy but powerful way to develop this knowledge. In additional to the basic board game, some new features were included in the ELA, developing other concepts concerning sensorics. Motivation, teamwork and application were also highlighted in the ELA, as well as other transversal competences.

This paper also shows the additional tools created for this activity, the main concerns and the overcome of some difficult challenges. Finally, outcomes from the activity are analysed and commented.

Keywords: experiential learning activities, robot, DOBOT, transversal competences.

1 INTRODUCTION

The evolution of industry towards automation is greatly influencing the development of education at medium and high levels. While the study of robotics was once a niche subject reserved for higher education and available to few, the augmenting presence of robots and automated machines in our industry increasingly requires students to learn these technologies. In fact, it is no longer reserved only for universities. High school and, especially, vocational training are leading the study of automatisms and robotics.

The problem hitherto has been the availability of material. Many schools are not able to afford the money necessary to build a robotic unit. The use of virtualisation has often been used in the development of higher education [1]. Robotics training has always been based on mounting small devices [2]. Johnson [3] recommended the study of robotics from early ages, since it is a multidisciplinary task that crosses knowledge barriers. However, robotics training in schools is not common [4]. Nevertheless, the emergence of new low-cost material, such as Arduino-based and low-cost robots, allows for the development of new forms of robotics learning.

In our opinion, one of the most efficient methods for this teaching-learning process is the use of experiential learning activities (ELA). Kolb [5] defines learning as a transformation of experiences. He develops a four-step cycle to achieve learning: experience (based on feeling), reflexive observation (based on watching), conceptualisation or abstract thinking, and active experimentation. Subsequent studies of this methodology ensure that the assimilation of concepts is much greater than with traditional teaching methodology, where there is a master class where students listen, repeat and memorise, but do not deepen their knowledge [6–8]. But surely, one of the greatest achievements obtained by ELA-based training is to clear the fears of failure and blockages due to the insecurity caused by a misunderstanding of the concepts. Through ELA, students acquire knowledge by experimenting, and the teacher guides them on their way [9]. In addition, ELA activities allow the critical development of teaching [10]. Of course, teaching must be supported by previous knowledge already acquired [11]. Our experience with other activities based on ELA [12–17] indicates that learning obtained with ELA is a much more positive experience than traditional learning.

In this paper, we develop the activity carried out with vocational students in a secondary school for the training of students in basic robotics concepts applying an ELA in conjunction with a typical table game: Tic-Tac-Toe.

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The article is organised as follows: In Section 2, we establish the work methodology, objectives and development. In Section 3, we analyse the results of the activity, and in Section 4, we show our conclusions.

2 METHODOLOGY

The main purpose of this study is aimed at students of non-compulsory education and, above all, technical training, but it is open to other levels. Robotics teaching jobs are generally oriented to higher levels [18] or basic levels, in which the material is based on LEGO or similar games [19–20]. This way of working does not always make the most of the students' implicit initial motivation for working with new technologies and often breaks an opportunity to acquire new knowledge.

In this study, the use of a simple tic-tac-toe game has been chosen to develop basic robotics concepts while students develop an experiential activity.

The realisation of experiential activities (ELA) requires a complete and exhaustive analysis of the concepts to be developed and the students to whom it is addressed. Laforge and Bushing [21] highlight the process necessary to plan an ELA effectively. Thus, it must be organised according to the scheme: planning, introduction, development and execution, and feedback.

2.1 Objectives

The initial step of all experiential activity is to determine the learning objectives. In this way, it is possible to establish the basic principles for the development of an ELA, as well as to place it in a work context. In our case, conceptual objectives are developed through experience, such as the concept of tolerance and the concept of hysteresis, in addition to knowing the components of a robot. Likewise, work procedures are developed for the management and programming of a simple robot, DOBOT Magician. The use of robot software is another highlight. Depending on the level of the student body, one of the two alternatives offered by the robot can be used: Scratch or C++. Last but not least, transversal competencies such as teamwork, negotiation and problem solving are developed.

The organisation of the activity is carried out following the usual structure of an ELA. First, a detailed planning of the activities is carried out, so that the teacher can establish a logical sequence of learning based on the main concepts to be developed. The learning process must also be summative and continuous, deepening the basic concepts before increasing the level [22], and always following the principles of scaffolding [23, 24]. Subsequently, the activity is developed, starting with an introduction of the problem to the student, a guided development and its execution, and, finally, a debate and discussion on the topic developed.

2.2 Planning

The planning phase must be elaborated in great detail in order to obtain positive results. The level of the students or the number of students can be decisive for the correct execution of the planned activities, since students have different learning styles [9, 25], although some authors think that this difference is not the case [26]. In any case, the planning process must have the possible casuistry of the classes, etc.

This activity is divided into three sessions of about three hours each. In the first session, the students' perspectives about their possibilities and the results they hope to obtain must be incorporated into the study, considering the job they want. Thus, following [27], we can establish the learning style to develop. The anticipation of material needs is important. In this article, we suggest a series of minimum conditions for the correct development of the activity. Table 1 shows the minimal material requirements.

Table 1. Minimal material requirements for the correct activity development.

	Activity 1	*Activity 2*	*Activity 3*
DOBOT Magician	1	2	1
Computer	1	2	1
Tic-Tac-Toe board	1	1	1
Initial survey	1	0	0
Feedback survey	0	0	1

2.3 Introduction

The introduction phase is essential to captivate students' attention. A correct presentation is important to motivate students [28] As this is an activity with high digital content, it can be lost in wandering by students [29, 30] so it is necessary to establish a work plan with them and make them aware that the work has a limited and sufficient time. At this time, an initial questionnaire is provided to measure capacity before performing the work.

The activity is carried out in groups, since there is no material available for each student. The first activity is to organise in groups. The teacher organises them according to an objective criterion. Groups of four participants are suggested.

It provides the first bases of how to position the robot, how to manage its movement, and how to get pieces and drop them. The use of a Magician DOBOT for this task makes the activity extremely easy. The positioning of the arm, as well as memorising the positions and subsequently managing it from a specific software, is very simple, and as it is a small educational robot, it poses no threat to students' safety.

After the first explanations, the tasks to be carried out in the next three activities are available. From here, the teacher should serve as a facilitator of ideas and should guide the students, who must find their own solutions to the problems that arise during the development of the activity.

2.4 Development and execution

The activity takes place in three sessions, which require knowledge of the previous activity for its realisation. It is not necessary to finish the activity to move on to the next stage, since conceptual knowledge is acquired throughout the activity itself.

2.4.1 Session 1

In the first session, contact is made with the DOBOT Magician. The robot is placed on the worktable, along with the game board. The students save the positions of the board and try to take the pieces from a certain buffer and leave them in certain positions. In this first phase, they check the needs of position tolerance of the robot at the time of placing the pieces, as well as the difficulties involved in the use of suction cups to be able to take the pieces. The nature of the material of the pieces to be taken may be fundamental, but it is considered by the authors that a simple demonstration is sufficient to acquire this concept.

For that reason, the robot must be placed within a set of marks in which the distance in the Y axis of the board is determined (it is essential in order to be able to place the board within the robot's working range). Figure 1 shows this initial positioning. The robot is placed in the dashed line interchangeably, so that the students work with this tolerance.

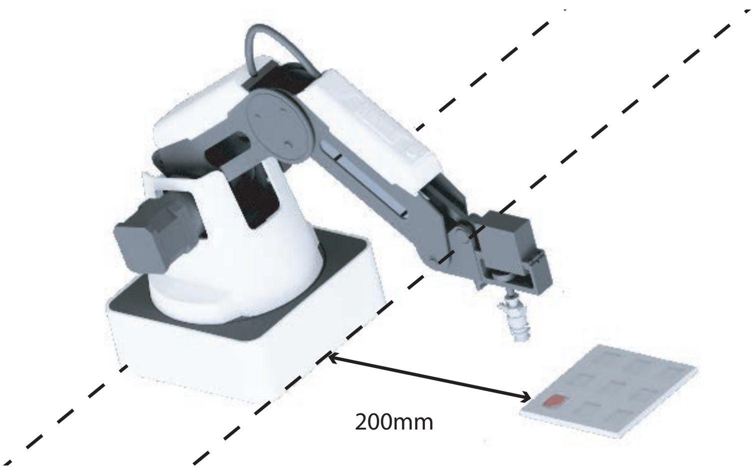

Figure 1. Robot and gameboard positioning.

At the programming level, learning is managed by understanding a pre-existing program. This program can be displayed in Scratch format or in C ++ format depending on the students' level of knowledge. Each level of programming is complemented by the previous one. A checklist allows students to guide their work.

To compile the training results, a series of templates is prepared for each group to fill out. Figure 2 shows the students' work templates. Once filled out, they are delivered to the teacher, who will evaluate them before the next session.

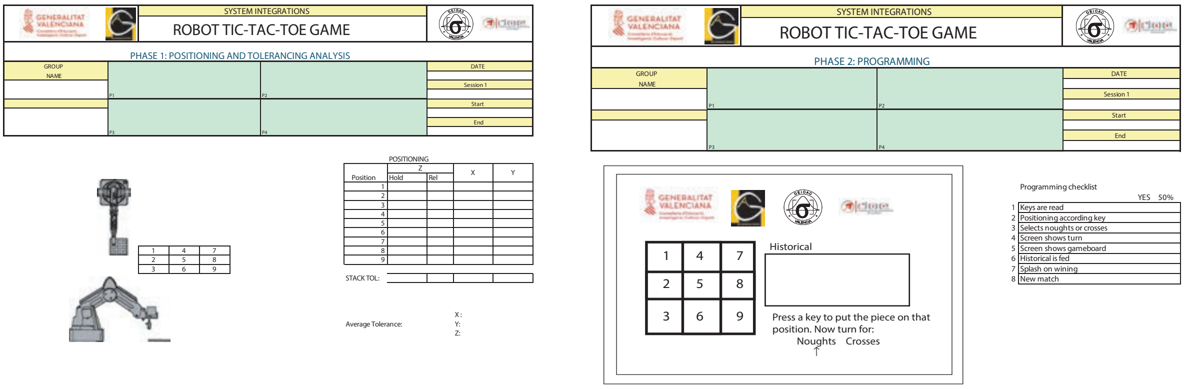

Figure 2. Students' work templates. Session 1.

2.4.2 Session 2

This session is aimed at collaboration and communication between different elements. They face two robots (one for each group), so that they communicate with each other and a game between players can take place. Prior knowledge is essential for this session, although even if students have not acquired 100% of the knowledge conveyed through this activity, it is possible to improve and reinforce it. New knowledge about communication allows both groups to communicate.

In the new situation, the parameters must be adjusted again, taking into account that the rival group also needs to do so. This allows the development of transversal elements, such as negotiation and understanding.

In this way, and following the theory of learning, previous knowledge is reinforced, and new knowledge is added. To assess the correct development of the situation, students have the template shown in Figure 3. This template is functionally similar to the previous one, but they must restore the parameters obtained in session 1.

In the case that some groups were not able to reach this level, the teacher can assemble the groups according to levels. The third session is individualised by groups, so that if there are groups that do not reach the minimum for this development, several levels can be established, so that some acquire new knowledge and others reinforce what has been seen so far.

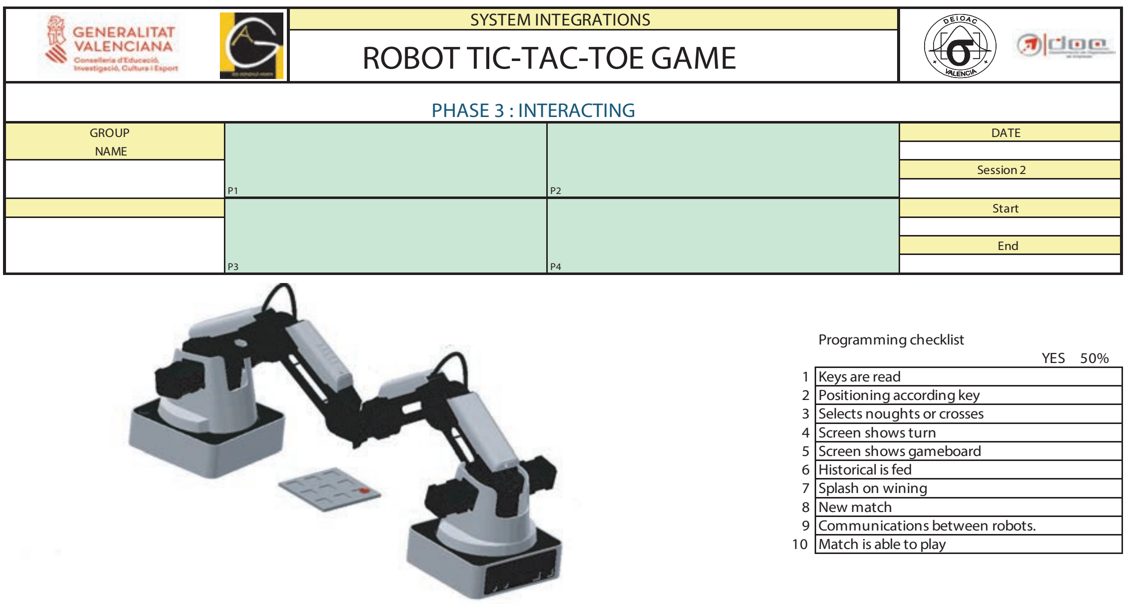

Figure 3. Work template for session 2.

2.4.3 Session 3

The third session seeks to fulfill the objective of learning and motivation by introducing a basic artificial intelligence. Although it is not about intelligence as such, it is intended that the robot will respond by itself to the moves made by a player. Each board layout must contain a response according to the play. The evaluation of the session is carried out using the template shown in Figure 4.

In addition, at this time, the robot must recognise at all times whether the card on which it is analysing is its own card or that of the opponent. To do this it is necessary to resort to the use of colour sensors. When working on this facet, students can observe how the different shades of the pieces can mark a critical point in the development of the activity.

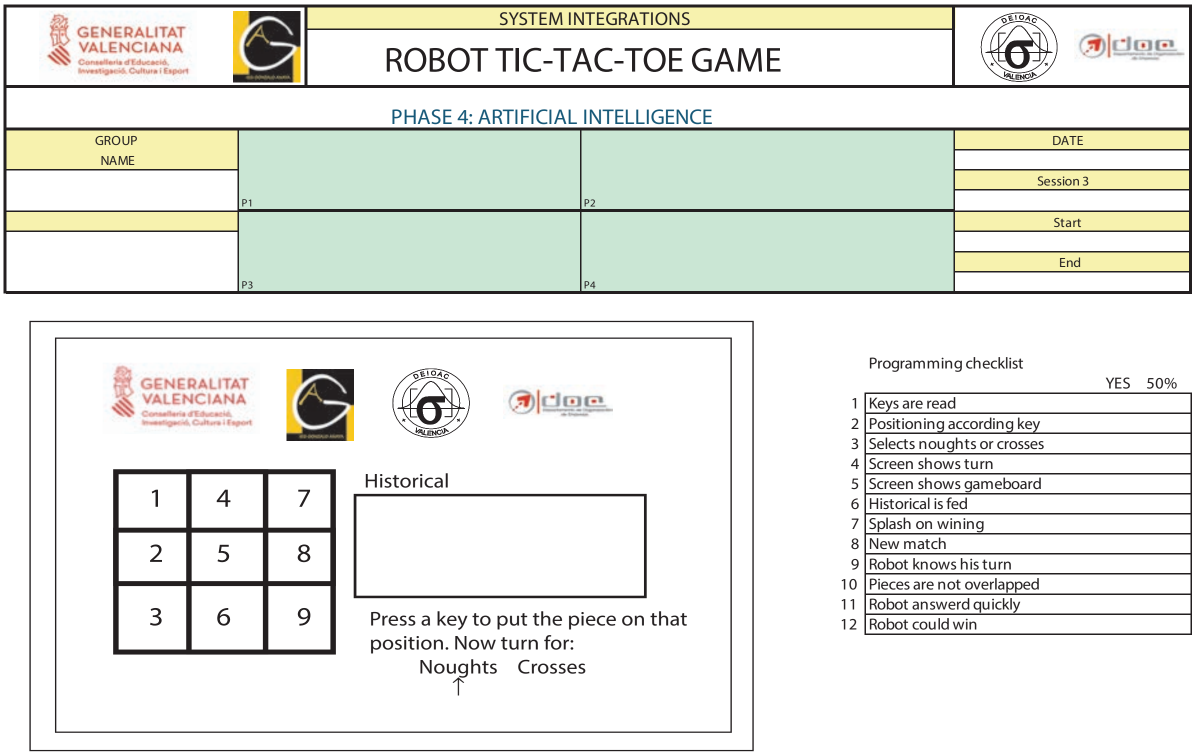

Figure 4. Work template for session 3.

2.4.4 Debate

The final session must reserve at least 15 minutes to discuss the knowledge acquired and the assessment of the activity itself for student learning. This phase is important to get the students to think critically about their learning [31–32].

3 RESULTS

The activity was carried out with eight students with professional training in the specialty of Senior Technician in Industrial Mechatronics. The students were aware at all times that the analysis of the conclusions would be useful for the future development of activities. This situation made the effort carried out by them superior to normal conditions. First, a questionnaire on technical skills was designed according to [27]. Twelve sets of three 5-point-scale questions were defined. The results are shown in Table 2.

From this table, we can consider that the students did not answer convinced of their skills on robotics. Confidence in their own skills is very low initially.

Table 2. Scale obtained on questionnaire

Position	Scale	Mean	SD
1	Helping and delegating	10.1	0.5
2	Adapting	6.3	0.8
3	Information gathering	8.4	1.2
4	Information analysis	5.6	1.4
5	Planning	6.5	1.2
6	Quantitative analysis	5.6	1.1
7	Technology management	8.4	2.2
8	Setting/managing to goals	8.6	2.1
9	Taking action	9	2.4
10	Entrepreneurship	9.1	1.2
11	Leadership	12.2	0.3
12	Relationship building	14.1	0.5

On Figure 5 we show two students during the experience learning activity. Motivation is a fundamental aspect in this teaching-learning methodology. Students find activities fun and learn through experimentation.

Figure 5. Two students learning robot positioning.

We also had a 5-point Likert scale form to assess the student's perception of the activity. Level 1 of the scale means 'disagree', while level 5 means 'totally agree'. The results are summarised in Table 3.

Table 3. Questionnaire and evaluation results of the activity.

Questions	Average
Does this activity help you in understanding robotics basics, such as movements and positions?	4.2
Did you learn about programming a robot?	4
Did you feel motivated to learn about the concepts developed in this activity?	4.8
To which extent do you find applicable the experience obtained in your future work?	4.6
Do you think the activity helped the group act as a team?	4.6

The results of the evaluation show that the teaching of robotics through ELA is possible, in addition to providing additional motivation to students. However, students' lack of knowledge in robotics and programming makes the results obtained difficult. Although they are students with the ability to program in C++, they did not choose this option, and decided to use Scratch.

4 CONCLUSIONS

In this document, we have presented an experiential learning activity (ELA) aimed at learning basic elements in robotics, such as positioning, interaction and communication. This is done by using a DOBOT Magician robot. A simple game like tic-tac-toe allows students to deal with positions and tolerances, as well as other movements. Although the activity is simple and has a game as a backbone, the acquired concepts are transferred directly to the industrial process.

Because the practice has been carried out in groups, transversal skills have been acquired without the student having the need to work on them.

The highly positive results of motivation shown in the feedback indicate that the activity has been perceived by the students in a positive way, although the students were not confident with their own skills and capabilities.

However, the activity needs to be enhanced and needs adjustments. Further developments on this activity are planned for the future.

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REFERENCES

[1] Candelas FA, Puente ST, Torres F, et al. A virtual laboratory for teaching robotics. Int J Eng Educ 2003; 19: 363-370.

[2] Scaradozzi D, Sorbi L, Pedale A, et al. Teaching Robotics at the Primary School: An Innovative Approach. Procedia - Soc Behav Sci 2015; 174: 3838-3846.

[3] Johnson J. Children, robotics, and education. Artif Life Robot 2003; 7: 16-21.

[4] Alimisis D. Educational robotics: Open questions and new challenges. Themes Sci Technol Educ 2013; 6: 63-71.

[5] Kolb DA. The process of experiential learning. En: Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall, *https://books.google.es/books*?hl=es&lr=&id=jpbeBQAAQBAJ&oi=fnd&pg=PR7&dq=Experiential+learning:+Experience+as+the+source+of+learning+and+development&ots=VmbRpRX-Nf&sig=jpzj5gVDMukGYz6D35rZ73eT4Yo (1984, accedido 10 de mayo de 2017).

[6] Kolb DA, Boyatzis RE, Mainemelis C. Experiential learning theory: Previous research and new directions. Perspect thinking, Learn Cogn styles 2001; 1: 227-247.

[7] Kayes AB, Kayes DC, Kolb DA. Experiential learning in teams. Simul Gaming 2005; 36: 330-354.

[8] Kolb AY, Kolb DA. Experiential learning theory: A dynamic, holistic approach to management learning, education and development. SAGE Handb Manag Learn Educ Dev 2009; 42-68.

[9] Kolb AY, Kolb DA. Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. Acad Manag Learn Educ 2005; 4: 193-212.

[10] Diane E. Halpern. Teaching Critical Thinking for Transfer Across Domains. Am Psychol 1997; 53: 449-455.

[11] Ausubel DP. The acquisition and retention of knowledge: A cognitive view. 2012.

[12] O. Trull-Dominguez, Peiro-Signes A, Segarra-Oña M. EXPERIENTIAL LEARNING ACTIVITY: OUTDOOR PASSAGE TO LEARN STATISTICS. En: 11th annual International Conference of Education, Research and Innovation. 2018, pp. 7374-7380.

[13] Peiro-Signes A, Trull-Dominguez O, Segarra-Oña M, et al. DEVELOPING AN EXPERIENTIAL LEARNING ACTIVITY TO LEARN ABOUT SMED. En: 11th annual International Conference of Education, Research and Innovation. 2018, pp. 7079-7084.

[14] Peiro-Signes A, Segarra-Oña M del V, Trull-Dominguez O, et al. Bean Bags: an Experiential Learning Activity for Quality Control. En: Proceedings of EDULEARN17 Conference. 2017, pp. 8216-8221.

[15] Peiro-signes A, Segarra-oña MV, Trull-dominguez O. Enrichment of Experiential Learning Activities. Proc EDULEARN17 Conf 2017; 3264-3269.

[16] Peiro-Signes A, Trull-Dominguez O, Segarra-Oña M del V, et al. Using Simple Experiential Learning Activities Encourage Learning of Operations Management Concepts. En: Proceedings of EDULEARN17 Conference. 2017, pp. 8712-8718.

[17] Peiro-Signes, A.; Alonso-Borso di Carminati, M. L.; Verdejo-Gimeno P. The experiential learning activity: benefits and difficulties in real learning environments. En: Proceedings of ICERI 2015 Conference. 2015, pp. 1150–1150.

[18] Berenguel M, Rodríguez F, Moreno JC, et al. Tools and methodologies for teaching robotics in computer science & engineering studies. Comput Appl Eng Educ 2016; 24: 202-214.

[19] Weinberg JB, Yu X. Robotics in education: Low-cost platforms for teaching integrated systems. IEEE Robot Autom Mag 2003; 10: 4-6.

[20] Tocháček D, Lapeš J, Fuglík V. Developing Technological Knowledge and Programming Skills of Secondary Schools Students through the Educational Robotics Projects. Procedia - Soc Behav Sci 2016; 217: 377-381.

[21] LaForge R, Busing M. The use of industrial software to create experiential learning activities in operations management course. Prod Oper Manag 1998; 7: 325-334.

[22] Halpern DFD, Hakel MDM. Applying the science of learning to the university and beyond: Teaching for long-term retention and transfer. Chang Mag High 2003; 35: 36-41.

[23] Hammond J, Gibbons P. What is scaffolding. Teach voices 2005; 8: 8-16.

[24] Sanders D, Welk DS. Strategies to Scaffold Student Learning: Applying Vygotsky's Zone of Proximal Development. Nurse Educ; 30, *https://journals.lww.com/nurseeducatoronline/* Fulltext/2005/09000/Strategies_to_Scaffold_Student_Learning__Applying.7.aspx (2005).

[25] Mainemelis C, Boyatzis RE, Kolb DA. Learning Styles and Adaptive Flexibility: Testing Experiential Learning Theory. Manag Learn 2002; 33: 5-33.

[26] Pashler H, Mcdaniel M, Rohrer D, et al. Learning Styles: Concepts and Evidence. Psychol Sci Public Interes 2009; 9: 105-119.

[27] Boyatzis RE, Kolb DA. From Learning Styles to Learning Skills. J Manag Psychol 1985; 10: 3-17.

[28] Ames C, Archer J. Achievement goals in the classroom: Students' learning strategies and motivation processes. J Educ Psychol 1988; 80: 260-267.

[29] Garris R, Ahlers R, Driskell JE. Games, motivation, and learning: A research and practice model. Simul Gaming 2002; 33: 441-467.

[30] Prensky M. Digital game-based learning. Computers in Entertainment (CIE) - Theoretical and Practical Computer Applications in Entertainment, 2003, pp. 21-24.

[31] Meyers C. Teaching students to think critically. San Francisco, CA: Jossey-Bass, 1986.

[32] Smith GF. Beyond Critical Thinking And Decision Making: Teaching Business Students How To Think. J Manag Educ 2003; 27: 24-51.