International Journal of Engineering & Technology, 7 (1.1) (2018) 246-251

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Applicability of Sudoku game for building the cognitive model of a student for career assessment - an analytical study

V. Chandra Prakash [1], J. K. R.Sastry [1], K.B.Anusha [2], A.B.Spandana [3]*, N. Dhatrija [3], V.Nikhil [3]

[1] *Professor Department of Computer Science & Engineering, Koneru Lakshmaiah Education Foundation,Vaddeswaram, Guntur, Andhra Pradesh, India-522502*

[2] *Scholar Department of Computer Science & Engineering, Koneru Lakshmaiah Education Foundation,Vaddeswaram, Guntur, Andhra Pradesh, India-522502*

[3] *Student Department of Computer Science & Engineering, Koneru Lakshmaiah Education Foundation,Vaddeswaram, Guntur, Andhra Pradesh, India-522502*

**Corresponding author E-mail: spandanaab@gmail.com*

Abstract

Career assessment helps a student understand how a variety of personal attributes (i.e., academic record, aptitudes, skills, preferences, motivations, etc.) impact his/her successful professional career and satisfaction. The professional life of a student is very much dependent on the initial choice of the career that the student would like to pursue. Nowadays, during job recruitment process, a student is assessed based on IQ tests, Verbal tests, Reasoning tests, etc. Every student has some psychological factors (i.e., decision-making, patience & perseverance, logical thinking, learning ability, etc.) that are not considered during these tests. As a result, some students may not lead successful careers in future. There are a very few ways to assess those psychological factors of a student and one such way is through Game playing. Through an analytical study, it was found that "Sudoku" is the best game to assess psychological factors, especially decision-making power, of a student. The authors proposed an Expert system that conducts Sudoku game for a student, assesses various psychological factors, builds a cognitive model of the student and provides career assessment.

Keywords: *Career Assessment; Cognitive Model; Expert System; Sudoku Game; Psychological Factors.*

1. Introduction

The selection of career is one of the most crucial decisions in a student's life. The right choice of career decides the professional life of a student. This right choice can be decided with the help of Career assessment. Normally, the career assessment is carried based on only the academic record, aptitudes, skills, etc. of a student. In present scenario, a student is recruited for a job basing on his/her performance in various tests viz. technical test, IQ tests, Verbal tests, etc. But, some of the very important psychological factors of a student are not considered during these tests. Because of this, sometimes some students may not fit well in their career in future. Hence, a career counsellor should also consider the student's psychological factors before deciding the career path so that in future the student can have a successful career in his/her professional life. These psychological factors of a student include decision-making power, patience & perseverance, logical thinking, learning ability, etc. The authors propose to assess these psychological factors through Game playing. As there are many games in the world, the authors have the problem of finding a very popular game that is suitable for assessing the psychological factors of the student. A few researchers suggested that Sudoku is one such game. In this paper, the authors have conducted an analytical study on the applicability of Sudoku game for building a cognitive model of a student that would be useful for career assessment.

1.1. Sudoku game

Bahare Fatemi, Seyed Mehran Kazemi et al. [3] stated that Sudoku is a very popular logic-based puzzle in Japan. Kedar Nath Das, Seyed Mehran Kazemi, et al. [7] stated that it is a pencil and paper game that was devised by an American architect, Howard Garnes in 1979 which is also considered as a combinatorial optimization problem. It is also known as "Number place", where "Su" signifies "number" and "Doku" signifies "single". It is played with digits ranging from 1 to 9. Sudoku can be found in various newspapers, magazines and mobiles. A Sudoku game and its solution are shown in Fig.1.

	7	5		9				6
	2	3		8			4	
8					3			1
5			7		2			
	4		8		6		2	
			9		1			3
9			4					7
	6			7		5	8	
7				1		3	9	

Copyright © 2018 V.Chandra Prakash et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1	7	5	2	9	4	8	3	6
6	2	3	1	8	7	9	4	5
8	9	4	5	6	3	2	7	1
5	1	9	7	3	2	4	6	8
3	4	7	8	5	6	1	2	9
2	8	6	9	4	1	7	5	3
9	3	8	4	2	5	6	1	7
4	6	1	3	7	9	5	8	2
7	5	2	6	1	8	3	9	4

Fig. 1: Sudoku Game and Its Solution.

- Rules to play:

Sudoku is rather tricky to solve, but the rules of the game are quite simple [3]. Solving a Sudoku game does not require knowledge of mathematics; it requires a simple logic. The objective of Sudoku is to enter a digit from 1 through 9 in each cell in a 9 by 9 grid, in such a way that, each horizontal row, each vertical column, each region or sub grid (3X3 matrix) contains each digit exactly once.

- Difficulty ratings:

Usually, Sudoku games available in newspapers are having different difficulty levels such as easy, medium and hard [7][8]. The number of given hints as digits in the game cannot determine the difficulty of a game. Timo Mantere and Janne Koljonen [6] stated that the difficulty level is based on where the number appears in the sub grids, but not on the quantity of numbers given. Yuan-hai XUE, Biao-bin JIANG et al. [1] also stated that the difficulty level of Sudoku is defined from four aspects as: total given cells, distribution of given cells, applicable techniques of logic deduction and complexity of enumerating search.

- Sudoku generator and solver:

Sudoku game has a generator and a solver. A Sudoku generator is responsible to generate a Sudoku grid with hints in specified cells of the grid. There may be a unique or multiple solutions for the given game. Christopher Chang, Zhou Fan et al. [5] proposed a method in which a Sudoku generator uses complete search algorithms so that each game can have a unique solution. The solver of Sudoku game provides solution(s) to the given game generated by a generator. Tjark Weber [4] proposed SAT-based Sudoku solver.

1.2. Psychological factors and cognitive model

A cognitive model of a student consists of different levels of the psychological factors like intelligence, speed of problem solving, perseverance & patience, etc. Daonilo Fum, Fabio Del Missier et al. [9] stated that Cognitive modelling is a form of validation. If the results obtained from the model match with those obtained by running experiments with human experts, then the model is said to be validated. Wayne D. Gray [12] stated that Cognitive modelling is used in real time systems on mainly two important domains namely human computer interaction and complex systems.

1.3. Career assessment

Chandra Prakash. V, J.K.R Sastry et al. [22] stated that Career assessment is used to help the students to decide for the right choice of career without any difficulty. An expert system is proposed by them which will assess the psychological factors of a student and build a cognitive model of the student. The system will use the cognitive model for career assessment. Chandra Prakash. V, J.K.R Sastry et al. [16] proposed an Expert System for assessing memory power of a student and career selection. Manisha L. Waghmode et al. [15] proposed an Expert system for best career selection.

2. Related work

- Generating, solving and rating sudoku game:

Yuan-hai XUE, Biao-bin JIANG et al. [1] devised an algorithm that creates Sudoku puzzles in varying level of difficulty. Shanchen Pang, Eryan Li [2] considered that the non-deterministic degree is regarded as the main factor that affects Sudoku puzzle. They developed a model that gives a metric to define the difficulty level of Sudoku puzzle based on information theory. They developed a model with an algorithm that can generate Sudoku puzzle according to the difficulty specified. Bahare Fatemi, Seyed Mehran Kazemi et al. [3] proposed a method for generating Sudoku puzzles using constraint satisfaction. They evaluated the difficulty of the Sudoku puzzles with the help of hill climbing algorithm. Tjark Weber [4] used constraint satisfaction search algorithms to solve Sudoku problems. The author showed that a good value ordering heuristic helps solving problems. The author also showed that Limited Discrepancy search is a good alternative to the traditional Forward Checking algorithm. Christopher Chang, Zhou Fan et al. [5] presented an unusual solution for the rating and creation of Sudoku puzzle with a difficulty level. For this difficulty metric, they created two puzzle generators for Sudoku. One generator generates easy to medium level Sudoku games with 4 levels and another generator generates hard level Sudoku games. Timo Mantere, and Janne Koljonen [6] have used Genetic algorithms for generating, rating and solving Sudoku games. Sudoku game is considered as a constraint satisfaction problem when it is handled with genetic algorithms. When solved with genetic algorithms it can be handled as a multi-objective optimization problem. Kedar Nath Das et al. [7] proposed a new algorithm called Retrievable Genetic algorithm for solving Sudoku puzzle. They found that Ret-GA functions are better than GA in most of the cases. Haradhan Chel et al. [8] proposed a multistage genetic algorithm (GA) for solving Sudoku. They found that their multistage GA provides reasonably good solutions for various Sudoku puzzles.

- Cognitive model

Lent, Robert W., Ijeoma Ezeofor et al. [10] presented two studies applying the social cognitive model of career self-management (Lent & Brown, 2013) to career exploration and decision-making outcomes in college students. Aaron T Beck, Emily AP Haigh [11] stated that Beck's cognitive model is used to formularize and treat psychological disorders. The generic cognitive model represents a set of ordinary principles that can be useful across the spectrum of psychological disorders. Chandra Prakash. V, J.K.R Sastry et al. [22] proposed an Expert system that plays Tic-Tac-Toe game with a student. Tic-Tac-Toe game is an intelligent game. It requires a good amount of intelligence, decision-making, etc. for a student in order to fight against a computer. The Expert system assesses the psychological factors of the student and builds a cognitive model of the student.

- Career choice and selection

Steven K. Mtsweni and Johnson O. Dehinbo [13] stated that selecting the best career is the most important aspect in student's life. While choosing the career, many students tend to follow the careers of their seniors but many times it happens that they may not fit in the selected career because of several factors. Hence, there is a need to develop an Expert system which can assess the capability of a student and guide him/her in choosing the most appropriate career. In this regard, a web application was designed and developed by the authors. Manisha L. Waghmode, Pallavi P. Jamsandekar [14] proposed a rule based Expert system that is useful for selection of proper career for students in a systematic way. The proposed framework was implemented for the design and development of the Expert system. Manisha L. Waghmode, Pallavi P. Jamsandekar [15] proposed an Expert system for career selection. They considered different parameters for assessing the student's strength and weakness. They collected domain knowledge from domain experts, and designed a framework of Expert system for career selection. They used different machine learning classifier algorithms for classifying data into different career streams using Weka tool. Chandra Prakash. V, J.K.R Sastry et al. [16] stated that Memory power of a student plays a major role in getting high academic record and also in selecting the appropriate career for the student. An Expert system is designed to assess the memory power of a student, build a cognitive model and identify the most suitable career(s) for the student.

- Career guidance

Yen-Ru Shi and Ju-Ling Shih [17] proposed that a game based career guidance system can be designed to help students to seek the best career. Ian Dunwell, et al. [18] developed a game called 'MeTycoon' that interacts with the learners and provides career guidance. It also encourages the teachers and professionals to give suggestions on career of the learner. This online game evaluated the learners based on questionnaires. S Saraswathi, et al. [19] designed an online Expert system which guides the students for the right choice of their undergraduate courses after the completion of higher secondary school education. By using pattern matching and jSoup parsing techniques, the construction of a knowledge base is done. Their Expert system gives faster advices based on the knowledge base. C. P. Ezenkwu, E. H. Johnson et al. [20] designed an automated career guidance Expert system using a technique called Case-based reasoning. It concentrates on the students who are poor at their academics and are not able to complete the academic program within the stipulated time. The Expert system helps in choosing the best career paths for the students based their abilities. Kasem Seng and Akram M. Zeki [21] designed a web based Career Guidance and Employment Management System (CGEMS) for the users who are seeking an advice on career or job. Their system conducts some tests or quizzes that are related to different career(s) and the user psychology and personality and those tests will be useful for selecting the best career path. Chandra Prakash. V, J.K.R Sastry et al. [22] stated that academic track record of a student is mainly considered by the consolers to provide career guidance for a student. But, apart from the academic record, a counsellor should also assess various psychological factors of a student viz. Intelligence, patience & perseverance, Learning ability, Speed of solving problems, etc. in order to provide a better career guidance. The authors designed an Expert system called “Tic-Tac-Toe Game Playing Career Guidance System” (TTT-GP-CGS) that is useful to assess the psychological factors of the student through Tic-Tac-Toe game playing, build the cognitive model of the student and predict the appropriate career(s) for the student.

- Career assessment and planning, mentoring system, support system, counselling

Petra Cook [23] explained how engineers can realize their full potential and overcome the obstacles to achieving career progression. They conducted a study called "Motivation Matters" which identifies the barriers to career progression which include lack of opportunities, lack of career guidance, and minimal provision of training & education programs. Ardeleanu Mircea [24] considered that Career guidance for high school graduates is important for their further personal and professional development. In their paper, they presented the link between a proper communication and career counselling. Ying-Chyi Chou, et al. [25] investigated the career assessment with respect to females. They discussed that the development of career possessed by female is not satisfactory according to their career needs. In their study, they compared the gaps and differences between the career needs and development support programs for females. Juhyun Jeon, and Jaeeung Lee [26] designed a Mentoring system for the college students to understand their needs, to seek a good professional career and meet the industrial demand. That is an effective way of designing an online mentoring system to improve the performance of the college students. Mohammed Abdallah Alimam et al. [27] proposed an automated system for matching scientific students to their appropriate career pathway based on science process skill model. Papadourakis et al. [28] presented a novel career counselling system which uses psychometric questionnaires to assess the personality of a person, the motives, the preferences for specific work environments, and the degree of sincerity (truth score) in the answers given. The psychometric factors are processed by the ARISTON Expert system which utilizes advanced mathematical and statistical models to create the personalized reports without any human intervention.

- Expert system

In Artificial intelligence, an Expert system is a computer system that emulates the decision-making ability of a human expert. It can solve problems. Expert systems are designed to solve complex problems by reasoning through knowledge base that is acquired from domain experts. Many researchers have proposed many Expert systems for career guidance [16], [22], [14], [15], [19], [20], [29], [30].

3. Applicability of Sudoku game to career assessment and guidance

In order to assess the career of a student, we have to consider the academic record and the cognitive model of a student. We should be able to assess the various psychological factors viz. intelligence, speed of problem solving, patience & perseverance, logical thinking, learning ability, etc. In this paper, we have investigated the applicability of Sudoku game to assess the psychological factors of the student. Once the psychological factors are assessed, we can build the cognitive model of a student. Basing on the cognitive model, an Expert system can predict the appropriate career(s) for the student.

3.1. Why Sudoku game?

Generally, Intelligence of a person can be assessed through IQ tests. There are many intelligent games in the world. We are in search of the best game for assessing the decision-making ability. We felt that Sudoku is the best game for assessing the psychological factor viz. decision-making ability. The rationale behind for selecting this Sudoku game for assessing psychological factors especially decision-making is as follows:

There are more than 1500 research articles on Sudoku game. There are more than 100 IEEE research articles and around 35 ACM research articles on Sudoku as of now. By seeing these figures, one can understand that Sudoku is one of the most popular games in the world and thus it is attracting many researchers. This game is a very challenging game because the player should have higher level of decision-making ability, intelligence, logical thinking, problem solving ability, patience & perseverance, etc. If the player is not strong in his/her psychological factors, then he/she can play this game, several times with patience and perseverance in order to improve his/her psychological skills. That is the reason why the authors have investigated on the applicability of this game to assess the psychological factors of the student. So, in future an Expert system can be designed which assesses the psychological factors of a student, builds a cognitive model and predicts the suitable career(s) for a student using Sudoku game playing.

3.2. Psychological factors

Psychological factors are related to thoughts, emotions and different cognitive capabilities that influence the mind-set, behaviour and features of the human mind. These factors can influence how a person thinks and later affect his/her decisions and relations in his/her daily life. These psychological factors include intelligence, logical thinking, problem solving ability, speed of problem solving, patience and perseverance, decision-making ability, learning ability etc.

3.2.1. Problem solving ability

The word "Problem Solving" means "a process of finding solutions to difficult or complex problems". Ability means "possession of the means or skill to do something". The problem solving ability depends on how a person understands, analyzes and provides solution to the given problem. An Expert system can assess the problem solving ability of a student quantitatively basing on the scores obtained by him/her when he/she plays the Sudoku game several times.

3.2.1.1. Speed of problem solving

The word "Speed" means "rate at which someone tries to solve a particular problem". The speed is dependent on how much time the student is taking to solve the Sudoku game. The speed of problem solving also depends on the difficulty level of the game. The system records the start time and end time of the current game played by the student and computes the difference, which is the time taken by the student to complete the game. Chandra Prakash. V, JKR Sastry et al. [22] stated that when a student plays Tic-Tac-Toe game a number of times, the average time of play of the student can be computed quantitatively. That average time reflects student's speed of problem solving.

3.2.1.2. Logical thinking

The word "Logical Thinking" means "the process of clearly moving from one related thought to another". In order to solve Sudoku game, the student must possess high level of logical thinking skills to understand the problem, find various strategies to solve the problem and apply the strategies to get the best solution to the given problem.

3.2.1.3. Decision-making ability

The word "Decision-Making" means that it is a cognitive process to select the best option among all other alternative options. Ian Dunwell, Petros Lameras et al. [18] presented an approach which uses a serious game called "MeTycoon" as a means to career guidance incorporating game-based elements such as character development and decision-making. Just like "MeTycoon", Sudoku is basically a logic oriented game. A student must possess high level of decision-making ability in order to solve the game in time and obtain better score.

3.2.1.4. Intelligence

There are many definitions for the word "Intelligence". One such definition is "The ability to apply knowledge and skills and solve the given problem". High level of intelligence is required for a student to solve Sudoku game in less amount of time and obtain better score. The score obtained by the student reflects his/her level of intelligence. Most of the times, a student with high intelligence maintains a better academic record and student with low intelligence may maintain a poor academic record, but there may be some stray cases. Chandra Prakash. V, J.K.R Sastry et al. [16] stated that, in some cases, a student with high intelligence may not study well and may not obtain good CGPA. It is also possible that another student with average intelligence may obtain good CGPA if he/she pays good attention and studies well.

3.2.2 Patience & perseverance

The word "Patience" means "an ability for willingness to suppress restlessness or annoyance when confronted with delay". In order to obtain good score in Sudoku game by the student, the student should possess a reasonable amount of patience. There are three levels in Sudoku game. The student can improve his/her score by playing the game for more number of times. If the student attempts only once or a few number of times, then he/she may be considered as impatient. A slow learner has to play this game a number of times with patience so that he/she can understand the game and later obtain good scores. The number of attempts made by the student and the time spent by the student reflect the level of patience of the student.
The word "Perseverance" means "commitment in doing something despite difficulty or delay in achieving success". Chandra Prakash. V, J.K.R Sastry et al. [22] stated in their paper, that the number of games played by the student reflects the student's patience and perseverance. If a student plays the Sudoku game several times either continuously or continually for a long time, in spite of difficulty or failures and finally achieves his/her expected score, then we can say that the student has good perseverance.

3.2.3. Learning ability

The word "Learning" means "the ability to comprehend and to understand from experience". The word "Ability" means "possession of the means or skill to do something". Chandra Prakash. V, J.K.R Sastry et al. [22] stated that when a student plays Tic-Tac-Toe game a number of times, if the scores obtained by the student is in increasing order, then we can say that the student has good learning ability.
In the initial stage of learning Sudoku game, a student may commit a few mistakes and thereby may get less score. He/she may learn from his/her experience on how to avoid the mistakes in future. For example, if a student completes a sub-grid and goes to solve next sub-grid and finds it difficult to proceed further, then he/she may backtrack quickly to previous sub-grid. Thus, the student learns this by experience. In such a case, we can say that the student has good learning ability. In order to assess the learning ability of the student, we can consider the gradual rise in scores obtained by the student.

3.2.4. Building the cognitive model

Using Sudoku game playing, an Expert system can assess the levels of various psychological factors of a student both quantitatively and qualitatively and build a cognitive model. Based on the cognitive model, a human or an Expert system can guess or predict what a student can do and what a student cannot do.

4. Discussion and proposed system

4.1. Discussion

During job recruitment, nowadays, a student is assessed based on his/her academic record, performance in aptitude tests, reasoning tests, technical tests, etc., but the student are not assessed based on his/her other psychological factors. The outcome of this analytical study is that Sudoku is the best game for assessing the psychological factors of a student. An Expert system can be designed which can conduct Sudoku game for a student and basing on the scores obtained by the student, it can assess the psychological factors and thereby build a cognitive model of the student. A human expert/Expert System can make use of the this cognitive model, student's academic record and scores obtained in different tests to predict the suitable career(s) for the student. Apart from the career assessment of the student, this research work can be extended to provide support for career counselling by counsellors (human experts) or Expert system.

4.2. Proposed system

The authors propose an Expert System for assessing the psychological factors of a student, build a cognitive model and provide career assessment. It is to be developed on a Java platform in order to run in a Client-Server environment. It should have the necessary security features. The functional requirements are shown below.

4.2.1. Registration

The student must register with the system providing the details like Name, ID number, Program of studying, Year of studying, CGPA (or) percentage, etc. so that later he/she is allowed to play Sudoku game.

4.2.2. Login

A student can login to the system by providing proper password so that the system can identify him/her as an authorized student.

4.2.3. Game playing and score display

The student will interact with the system and plays Sudoku game at different levels. In this game, there are 3 levels, viz. Easy, Medium and Hard. In each level, certain number of games are to be played by the student. After playing the game, the score obtained by the student will be displayed.

4.2.4. Cognitive model and career assessment

Based on the scores obtained by the student, the Expert System will assess the psychological factors of the student quantitatively and builds the cognitive model of the student. The cognitive model also includes the student's academic record. The list of the careers and details regarding the levels of psychological factors that are required to pursue the career are collected from domain expert(s). Based on the cognitive model, suitable career(s) of the student is suggested by the Expert System.

5. Conclusion

There are many games in the world. The authors has conducted a survey to choose the best game that can be played by the students so that an Expert System can assess the psychological factors of the students quantitatively. We found out that Sudoku game is the best option among all other games. A study is carried out to analyse the applicability of Sudoku game for Career Assessment of a student. In future, an Expert System can be designed to assess the psychological factors using the Sudoku game and build the cognitive model for the student. Based on the cognitive model, the suitable career(s) can be suggested for the student.

Acknowledgement

This research work is part of the research project titled "Development of an Expert System for career assessment based on cognitive model" funded by Department of Science and Technology - Cognitive Science Research Initiative scheme(CSRI) (Sanction order No SR/CSRI/129/2014(G)) of Government of India. The PI of the project is Dr. V. Chandra Prakash. The Co-PI of the project is Dr. J.K. R. Sastry. The infrastructure for the project is provided by K L University.

References

[1] Yuan-hai XUE, Biao-bin JIANG, Y. Li, Gui-feng YAN, and Hua-fei SUN, "Sudoku puzzles generating: From easy to evil." Mathematics in practice and theory 21, no. 000 (2009).

[2] Shanchen Pang, Eryan Li, Tao Song, and Peng Zhang. "Notice of Retraction Rating and Generating Sudoku Puzzles." In Education Technology and Computer Science (ETCS), 2010 Second International Workshop on, vol. 3, pp. 457-460. IEEE, 2010.

[3] Bahare Fatemi, Seyed Mehran Kazemi, and Nazanin Mehrasa. "Rating and Generating Sudoku Puzzles Based On Constraint Satisfaction Problems." World Academy of Science, Engineer-ing and Technology, International Journal of Computer, Elec-trical, Automation, Control and Information Engineering 8, no. 10 (2014): 1816-1821.

[4] Tjark Weber. "A SAT-based Sudoku solver." in LPAR, pp. 11-15. 2005.

[5] Christopher Chang, Zhou Fan, and Yi Sun, "A Difficulty Met-ric and Puzzle Generator for Sudoku.", UMAPJournal (2007): 305.

[6] Mantere, Timo, and Janne Koljonen. "Solving, rating and generating Sudoku puzzles with GA." In Evolutionary Compu-tation, 2007. CEC 2007. IEEE Congress on, pp. 1382-1389. IEEE, 2007.

[7] Kedar Nath Das, Sumit Bhatia, Shubhin Puri, and Kusum Deep. "A retrievable GA for solving Sudoku puzzles." Technical report (2012).

[8] Haradhan Chel, Deepak Mylavarapu, and Deepak Sharma. "A novel multistage genetic algorithm approach for solving Sudoku puzzle." In Electrical, Electronics, and Optimization Techniques (ICEEOT), International Conference on, pp. 808-813, IEEE, 2016. https://doi.org/10.1109/ICEEOT.2016.7754798.

[9] Danilo Fum, Fabio Del Missier, and Andrea Stocco. "The cognitive modelling of human behavior: Why a model is (some-times) better than 10,000 words." (2007): 135-142.

[10] Lent, Robert W., Ijeoma Ezeofor, M. Ashley Morrison, Lee T. Penn, and Glenn W. Ireland. "Applying the social cognitive model of career self-management to career exploration and decision-making." Journal of Vocational Behavior 93 (2016): 47-57. https://doi.org/10.1016/j.jvb.2015.12.007.

[11] Beck, Aaron T., and Emily AP Haigh. "Advances in cognitive theory and therapy: the generic cognitive model." Annual review of clinical psychology 10 (2014): 1-24. https://doi.org/10.1146/annurev-clinpsy-032813-153734.

[12] Gray, Wayne D. "Cognitive modeling for cognitive engineer-ing." The Cambridge handbook of computational psycholo-gy (2008): 565-588.

[13] Steven K. Mtsweni and Johnson O. Dehinbo. "Development and Usability of a Web Application for Career Choice for High School Students." In Proceedings of the World Congress on Engineering and Computer Science, vol. 1. 2013.

[14] Manisha L Waghmode , P PJamsandekar, Expert system for Career Selection: Theoretical Framework, Volume 4, Issue 8,August 2016 International Journal of Computer Science, ISSN: 2321-5992.

[15] Manisha L Waghmode , P PJamsandekar, Expert system for Career Selection: A Classifier Model, Volume 4, Issue 1,January 2016 International Journal of Advanced Research in Computer Science and Management Studies, ISSN: 2321-7782.

[16] V. Chandra Prakash, J. K. R. Sastry, V. Kantharao, V. Sri-harshini, G. Sriram, and C. H. V. S. Ganesh. "An Expert Sys-tem to assess memory power of a student for selection of a suitable career" (2017): 309-321.

[17] Yen-Ru Shi and Ju-Ling Shih. "Game-Based Career Guidance Systems Design Concept." In Digital Game and Intelligent Toy Enhanced Learning (DIGITEL), 2012 IEEE Fourth Inter-national Conference on, pp. 187-191. IEEE, 2012. https://doi.org/10.1109/DIGITEL.2012.53.

[18] Ian Dunwell, Petros Lameras, Sara de Freitas, Panos Petridis, Kam Star, Maurice Hendrix, and Sylvester Arnab. "MeTycoon: A game-based approach to career guidance." In Games and Virtual Worlds for Serious Applications (VS-GAMES), 2013 5th International Conference on, pp. 1-6. IEEE, 2013. https://doi.org/10.1109/VS-GAMES.2013.6624237.

[19] S. Saraswathi, M. Hemanth Kumar Reddy, S. Udaya Kumar, M. Suraj, and Sk Khaja Shafi. "Design of an online Expert system for career guidance." The International Journal of Re-search in Engineering and Technology 3 (2014).

[20] C. P. Ezenkwu, E. H. Johnson, and O. B. Jerome. "Automated Career Guidance Expert System Using Case-Based Reason-ing."

[21] Kasem Seng, and Akram M. Zeki. "Career Guidance and Employment Management System." In Advanced Computer Sci-ence Applications and Technologies (ACSAT), 2014 3rd In-ternational Conference on, pp. 73-78. IEEE, 2014.

[22] V. Chandra Prakash, J. K. R. Sastry, B.Mohana Priyanka, K.Pavan Kumar, Ch.Deepika and N. Pavan Kalyan Yadav. "Assessing the intelligence of the student through Tic-Tac-Toe game for Career Guidance" (2017): 565-572.

[23] Petra Cook. "Breaking the barriers to career progression [career planning]." Engineering Management 16, no. 2 (2006): 31-33. https://doi.org/10.1049/em:20060207.

[24] Ardeleanu Mircea "Professional communication-support in guiding young people toward a higher technical education." In Fundamentals of Electrical Engineering (ISFEE), 2014 In-ternational Symposium on, pp. 1-6. IEEE, 2014.

[25] Ying-Chyi Chou, Hsin-Yi Yen, and Ju-Miao Yen. "The as-sessment of career needs and development programs of female technology talents." In Technology Management in the Energy Smart World (PICMET), 2011 Proceedings of PICMET'11:, pp. 1-8. IEEE, 2011.

[26] Juhyun Jeon, and Jaeeung Lee. "Implementation of mentoring system in college for smooth transition to work." In Interactive Collaborative Learning (ICL), 2015 International Conference on, pp. 1181-1183. IEEE, 2015. https://doi.org/10.1109/ICL.2015.7318202.

[27] Mohammed Abdallah Alimam, Hamid Seghiouer, Mohammed Amine Alimam, and Mohammad Cherkaoui. "Automated system for matching scientific students to their appropriate ca-reer pathway based on science process skill model." In Global Engineering Education Conference (EDUCON), 2017 IEEE, pp. 1591-1599. IEEE, 2017.

[28] Papadourakis, George M., Eva Foudoulaki, John E. Yannakoudakis, and Marianna Alogdianaki. "An Expert Systems Approach to Career Counselling."

[29] Athanasios Drigas, Stelios Kouremenos, Spyros Vrettos, John Vrettaros, and Dimitris Kouremenos. "An Expert sys-tem for job matching of the unemployed." Expert Systems with Applications26, no. 2 (2004): 217-224. https://doi.org/10.1016/S0957-4174(03)00136-2.

[30] Essaid El Haji, Abdellah Azmani, and Mohamed El Harzli. "Expert system design for educational and vocational guid-ance, using a multi-agent system." In Multimedia Computing and Systems (IC-MCS), 2014 International Conference on, pp. 1018-1024. IEEE, 2014.