

Expert system for building Cognitive model of a student using Crypt Arithmetic game and for Career Assessment

V. Chandra Prakash, V. Kantharao , JKR Sastry, V. Bala Chandrika

Abstract— During the academic life of a student, predicting a suitable career(s) of the student is of paramount importance because the suggested career would be the goal of the student to achieve. Hence, the student has to select appropriate core courses and electives accordingly so that he/she can acquire knowledge and skills appropriate to that career. Generally, the job of predicting career(s) is done by the expert counsellors in the institution. These counsellors consider the academic track record of the student and also the marks secured in subjects like aptitude, reasoning tests, etc. Many times, when a student completes his/her graduation and gets a job in industry, his/her psychological factors may not match with the psychological factors that are required for that job. This results in frustration.

An expert system is required using which the Psychological factors of a student can be assessed by making the students play a game. In this paper “crypt arithmetic game” has been presented and a way has been shown how psychological factors can be assessed using the game. It has also been presented in this paper the way a suitable career that matches psychological factors can be predicated.

Keywords: Crypt arithmetic Game; Assessing Psychological Factors; Cognitive Model; Career Assessment; Expert System; problem solving ability; Patience and Perseverance; Learning ability.

1. INTRODUCTION

1.1. Career assessment

Many Psychological factors of a student must be taken into account that includes ability to solve the problems, perseverance, patience which directly affects the career of a student. The psychological factors of the student can be assessed by making the student play a computerised game called “Crypt arithmetic game”. Each psychological factor is computed based on a scale of computation making it possible to assess suitable career of the student considering the level of psychology of the student.

There are many popular ways to assess Intelligence, Aptitude and Reasoning ability of a student through different tests viz. IQ tests, aptitude test, etc. Other than these methods,

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Intelligence of a candidate can also be assessed while solving brain teasing puzzles. Solving Cryptarithmic puzzle is one such technique by which a student’s psychological factors can be assessed by an expert system.

An expert system will help generating a game that should be played by the student such that the problem is solved by inventing a proper solution. While the student is playing the game several counts are accumulated that reflect the Psychology of the student playing the game. Counts are the scores accumulated while the student is playing the Game. An automated expert system can be used to predict the career that is most suitable to the student based on the score achieved for each of the psychological factor.

1.2 Crypt Arithmetic Problem

Mathematical games provide fundamental platform available for making the students to play the games and by doing so, provide the basis for assessing the capabilities of the students. Many games are in existence and one of the most important games is crypto Arithmetic game. Mathematical equations are formed among the unknown numbers. The digits of each of the number are represented by English letters. The students should be able to find the values of the letters such that the mathematical equations hold good considering the arithmetic that includes add, subtract, multiply and divide.

The classic example is adding SEND+MORE to get MONEY. The user shall have to select a numerical value to each letter such that the equation holds good. Selection of values viz. D=7, E=5, M=1, N=6, O=0, R=8, S=9, Y=2 implies that $1085 + 9567 = 10652$. Each letter must be assigned with unique value different from the digits assigned to other letters. The words used in the Mathematical expressions must form into phrases.

1.3. Why to assess psychological factors

Career assessment is one of the most important tasks in student’s academic life. Based on the career recommended by expert system, a student will be able to select appropriate subjects and electives in his/her future studies to choose the best career path in student’s life. Career assessment is mainly important for final year students to find what jobs for which

they are suitable in software industry. Hence, it is very



important for the expert system to assess the psychological factors of a student such as intelligence, patience and perseverance levels, etc.

1.4. Cognitive model

The level of psychology of a student could be fixed through a level assigned to each of the Psychological factor. It is possible to fix a level for each of the Psychological factor that include speed of problem solving, judgement, patience, memory, reasoning ability, concentration power, learning ability, decision making etc.

1.5. Expert system

It is a system that is built using Artificial Intelligence techniques. It simulates the behaviour of a human expert. It has a knowledge base, a database, an inference engine and an interface.

2. RELATED WORK

The following provides a survey of literature in this direction.

2.1. Crypt Arithmetic

The roles of computers in analysing the puzzles have been investigated by Higashide, Hiroshi [1]. They have presented that crypt arithmetic can be presented as computer programs making it as a suitable and effective method for analysing the abilities of the students which are required for pursuing different careers

A method that uses a parallelization for solving Cryptarithmic Problems has been presented by Rahnavard, Gholamali, and Gholamhossein Dastghaibyfarid [2]. The authors have shown that the method employed by them requires less number of iterations and also getting the solution in least time.

Genetic algorithms have been used by Abbasian, Reza, and Masoud Mazloom [3] to solve the problems that can be represented based on crypt arithmetic. The process of optimisation has also been employed as a part using the genetic algorithms. They have shown that solution to the complex problems can be achieved within little iteration and in minimum time.

Verbal crypt arithmetic problems have been solved by using parallel genetic algorithm combined with depth first search algorithm by Naoghare, M. M., and V. M. Deshmukh [4]. The authors have applied their approach and solved many complex problems and proved that the solutions to the problems can achieved in minimum time.

A solution has been presented by Minhaz, Aadil, and Ajay Vikram Singh [5] for solving a Crypt arithmetic Problem. The solution proposed by them is based on parallel genetic algorithm.

Social Learning Heuristics are used by Fontanari, José F. [6] for solving many of the crypt arithmetic problems. They have presented the way crypt arithmetic problems can be solved using a group of cooperating agents. They have justified that a group of cooperating agents can find the solutions quite quickly rather than independent agents. They have carried extensive simulation of their studies to justify their premises.

2.2. Expert system

Decision making ability of a person can be simulated through an expert system in which artificial intelligence is heavily used. Every expert system is built in two parts that include an inference engine and a knowledge base. Facts and rules form the Knowledge base, The applicability of the rules to the known facts is undertaken by an inference engine leading to finding more new facts. The guiding phenomenon of the applicability of the rules can also be explained using empirical formulas. Expert systems are being used heavily in the fields viz. education, mining, medical, agriculture, etc.

Asabere, Nana Yaw [6] designed and developed a mobile medical expert system for health institutions in Ghana. Zeki, Tawfik Saeed, Mohammad V. Malakooti, Yousef Ataeipoor, and S. Talayeh Tabibi [7] designed and developed an expert system for diabetes diagnosis. Khanna, Satvika, Akhil Kaushik, and Manoj Barnela [8] investigated on the use of expert system in education. They found that expert systems are extremely useful in the following fields of education. (1) educational planning and decision-making ability (2) teacher training (3) intelligent tutoring. Asabere, Nana Yaw, and Simonov Kusi-Sarpong [9] designed and developed a mobile vehicle expert system for the automobile industry. Jabbar, Haider Khalaf and Rafiqul Zaman Khan [10] have made an extensive survey on development of expert system in the areas of Medical, Education, Automobile and Agriculture.

2.3. Cognitive model and expert system for career prediction

A critical analysis of Sudoku game has been carried by Chandra Prakash et al. [11] and it was found that the game is most suitable for assessing various psychological factors especially to assess the decision making power of a student. Chandra Prakash et al. [12] have also conducted a deep analysis to find how the sokoban game can be used to assess the planning capability of the students. An expert system has been built considering the psychological factors that can be assessed through Sudoku game. The end objective of this effort is to predict suitable careers that can be pursued by the students.

An expert system has been designed and developed built based on Tic-Tac-Toe and the same is also used for predicting the most suitable careers to the students Chandra Prakash et al. [13]. In Tic-Tac-Toe game, the first player is a student and the second player is an expert system that uses Artificial Intelligence (AI) techniques to play the game. The capacity of the student to play the game against the computer is assessed. A cognitive model of the system is built which comprises of various psychological factors and the corresponding levels of the student. A matching process is carries out by the system to predict suitable careers for the student. Chandra Prakash et al. [14] designed and developed an expert system to assess the memory power of a student for selection of a suitable career.

An expert system has been



developed by Chandra Prakash et al. [15] using which several psychological factors of a student can be assessed while the student keep solving 8- puzzle game generated by the Expert system. A cognitive model of the student is built which leads to career prediction for the student.

3. DESIGN OF EXPERT SYSTEM FOR GAME PLAYING AND CAREER PREDICTION

For assessing suitable career for a student, a cognitive model, and an academic record of the student are required. The psychology of the students must be assessed for constructing the cognitive model that is more suitable for assessing the student's abilities that are required for doing an assigned job most appropriately. While many psychological factors can be selected, the most important are patience & perseverance, intelligence, problem solving ability, learning ability, etc. Puzzles which are of type "crypt Arithmetic" help in finding the psychological factors of the students when the students are made to solve the problems. A cognitive model can be built using the psychological factors. The model is useful in assessing the level achieved by each of the students considering different psychological factors that can be evaluated through Crypto Arithmetic games. Scores are computed for each of the Psychological factors while the students keep playing the crypt games. The scores are used to build the cognitive model. The cognitive model thus built can be used to assess suitable career to a student.

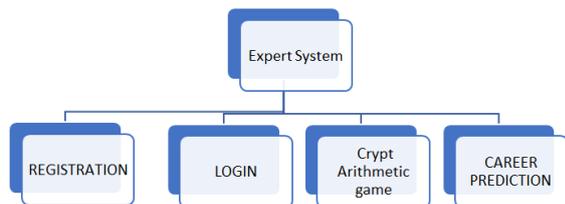


Fig.1: Architecture of Expert System

3.1 Registration

Before playing crypt arithmetic game, every student has to undergo the processes of registration. In the registration process, the student has to provide his/her register number, name, phone number, password, etc.

3.2. Login

The student has to login with username and correct password. This module is for security.

3.3. Game playing

Once the login process is completed, the student is allowed to interact with the system. The system maintains a collection of crypt arithmetic puzzles in a knowledge base. The collection is divided into 3 categories. Viz. easy, medium and hard levels. For each puzzle, there may be one or multiple solutions. The system maintains all the solutions for all puzzles. The student has to solve puzzles of all levels. At each level, the system picks up a puzzle randomly from the collection. The student has to find the solution for the puzzle displayed on the screen. If the student's solution matches with any of the solutions available in the knowledge base, then the system assigns the score for the student.

At easy level, the student has to solve at least 3 puzzles, and the system awards maximum of 3 marks. Then the student has to solve a minimum of 3 puzzles of medium level and the maximum score allotted for that level is 3. The student has to solve more puzzles in order to obtain his/ her score in patience & perseverance. Next, the student has to solve puzzles of hard level and the maximum score allotted for that level is 4. In total, the maximum score is 10.

Basing on the total score obtained by the student, the system can assess the levels of the psychological factors of the student, build the cognitive model of the student and thereby predict suitable careers for the student. Some of the puzzles in the knowledge base are as follows.

Examples of Addition

- 1 CAT + DOG = PET
- 2 BIG + CAT = LION
- 3 CLOCK + TIME = ALARM
- 4 HORN + SIREN = SOUND
- 5 PLAY + FOOT = BALL

Example for subtraction:

$$\text{FIVE} - \text{FOUR} = \text{ONE}$$

$$\text{Solution } 1486 - 1230 = 256$$

Example for multiplication:

$$\text{SIX} * \text{TWO} = \text{TWELVE}$$

3.4. Assessing psychological factors.

Psychological factors are related to human problem-solving ability, patience, perseverance, learning ability, etc. of the student. These factors reflect the mental capacity of the student and define the person's thinking abilities, decision making power. They have major influence in his/her day-to-day life.

After completion of the game, basing on the score obtained by the student, the proposed system can assess the psychological factors of the student viz. intelligence, problem solving ability, patience, and perseverance.

3.4.1. Assessing Problem solving ability.

Adhoc and generic methods are used in some orderly manner for finding solutions to some complex problems. Many problem solving methods have been discussed and presented in the fields of engineering, Medicine, computer science, artificial intelligence, deep learning and machine learning. Some of these methods can also be used for solving problems that are traced in the field of Cognitive science especially related to solving problems related Psychology assessment.

When a problem is given to a student, he/she has to understand the goal of the problem. He/she may be able to identify the rules/algorithms/ techniques that could be applied to the problem so that the candidate may find the key to solving the problem. Sometimes, the candidate may use abstract thinking or exhibit creativity in order to find solution

to the problem. In general, we can expect that a student



with high academic record will secure high score in solving Crypt arithmetic problem and a student with low academic record may secure low score. Table 1 shows the quantitative and qualitative aspects of the score in problem solving ability.

Table:1 Problem Solving Ability

S. No	Score in Problem solving ability (Quantitative)	Score in Problem solving ability (Qualitative)
1.	≥ 9	Excellent
2.	$\geq 7 \ \& \ < 9$	Very Good
3.	$\geq 6 \ \& \ < 7$	Good
4.	$\geq 3 \ \& \ < 6$	Moderate
5.	$\geq 0 \ \& \ < 3$	Low

3.4.2. Assessing Patience & Perseverance.

The number of puzzles successfully solved by the student at medium level or hard level are considered for assessing the level of the patience and perseverance of student. Refer to the Following table 2 for quantitative and qualitative measurements.

Table:2 Patience and Perseverance.

S. No.	Count of Games played (Quantitative)	Score in Patience and perseverance (Qualitative)
1.	≥ 10	Very Good
2.	$\geq 3 \ \& \ < 10$	Good
3.	< 3	Low

3.4.3. Assessing Learning Ability

The Learning ability of a student directly depends on the score obtained by the student while solving the crypt arithmetic problem. The following table 3 shows how to calculate the learning ability of a student.

Table 3: Learning ability

S. No.	Score in Learning Ability (Quantitative)	Score in Learning Ability (Qualitative)
1.	$\geq 8 \ \& \ \leq 10$	Excellent
2..	$\geq 7 \ \& \ < 8$	Very Good
3.	$\geq 6 \ \& \ < 7$	Good
4.	$\geq 3 \ \& \ < 6$	Moderate
3.	$\geq 0 \ \& \ < 3$	Low

3.5. Finding suitable careers.

Generally, a career is selected for a student depending on his/her academic track record that is reflected by Cumulative Grade Point Average (CGPA). We propose that, apart from the candidate's CGPA, various psychological factors are also to be considered while selecting the suitable career(s) for the student. Table 4 shows some identified careers and CGPA and quality of various psychological factors required to perform the job.

Earlier, various psychological factors of the student were assessed both quantitatively and qualitatively. A process is carried on to match the student's psychological factors with those factors that are required for each career (refer Table 6) and the suitable career(s) are recommended for the student. A Report displays the career(s) suitable to the students.

Table 4. Career VS Required Academic Record and Psychological Factors.

S. No.	Career	CGPA	Quality of Psychological Factor		
			Problem Solving ability	Patience perseverance	Learning Ability
1.	Software Engineer	≥ 7.5	Excellent	Good	Excellent
2.	Software Maintenance Engineer	≥ 7	Very Good	Very Good	Very Good
3.	Software Tester	≥ 6.5	Good	Very Good	Good
4.	Marketing Person	< 6.5	Moderate	Very Good	Moderate

4. RESULTS ANALYSIS AND DISCUSSION

A set of students belonging to final year B. Tech (Computer Science and engineering) students solved Crypt arithmetic puzzles given by the system and the scores of the students are shown in the table 5. The system predicted the suitable career(s) for the students using Table 4. The student's Roll number, CGPA, psychological factors and the highest career for which he/she is suitable are shown in the Table 6.

Table 5: Problem Solving score Vs CGPA

S.No.	Roll No.	CGPA	Score
1	13	3.4	2
2	45	4.5	4
3	56	5.0	4
4	66	5.5	8
5	69	5.8	5
6	25	6.7	6
7	11	6.9	6
8	7	7.2	7
9	61	7.5	4
10	43	8.5	8
11	21	9	8
12	35	9.2	9



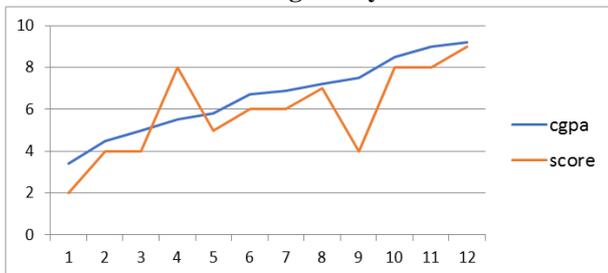
Table 6. Student VS Recommended career(s)

S. No.	Roll No.	CGPA	Problem solving ability	Patience & Perseverance	Learning Ability	Recommended Career
1.	35	9.2	Excellent	Good	Excellent	Software Engineer
2.	43	8.5	Excellent	Good	Excellent	Software Engineer
3.	7	7.2	Very Good	Very Good	Very Good	Software maintenance engineer
4.	11	6.9	Good	Very Good	Good	Software Tester
5.	45	4.5	Moderate	Very Good	Moderate	Marketing Person

the expert system is rightly assessing the psychological factor i.e., problem solving ability.

We can observe, in general, that if a student exhibits good intelligence, he/she also gets good marks and maintains a good academic record. Generally, we can expect that if a student has high academic track record (CGPA) then he possesses a very high level of problem-solving ability. Similarly, if a student has low CGPA, we can similarly expect that he possesses low level of problem-solving ability. Of course, it is also possible, in rare cases that a student may possess high level of problem-solving ability but maintains low academic track record. One of the reasons for this anomaly could be that the student does not study well. Table 5 shows student's problem-solving score and CGPA. Considering the table 5, two graphs are shown chart-1. First graph represents student vs CGPA and second graph represents student vs score in problem solving.

Chart-1: Graphs depicting CGPA & score problem solving ability

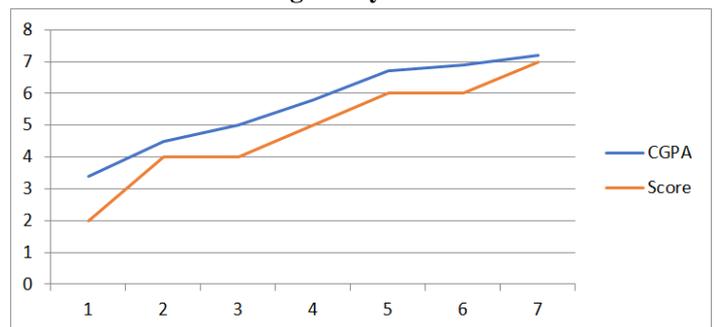


In the above graph representing the score of the students, we can observe that one student, who has low CGPA but secured high score in problem solving ability. The reason behind this may be that either the student is not having good memory power or lack of interest in that particular course. There is another case of student, who has high CGPA but secured low score in problem solving ability. The reason behind this may be that either the student did not show much interest in solving the crypt arithmetic puzzles or the student has really low-level ability in problem solving. These students are considered to be outliers. We can revise the table 5 by removing the outliers and obtain the table 7. Again, the graphs are plotted using revised table 7 (refer Chart-2). In the chart-2, both the graphs are similar indicating that the score is somewhat proportional to the CGPA of the students. Thus, a correlation is established between CGPA and problem-solving ability of the students. This is the proof that

Table 7: CGPA & Score in problem solving –Revised

S.No.	Roll No.	CGPA	Score
1	13	3.4	2
2	45	4.5	4
3	56	5	4
4	69	5.8	5
5	25	6.7	6
6	11	6.9	6
7	7	7.2	7
8	43	8.5	8
9	21	9	8
10	35	9.2	9

Chart-2: Graphs depicting CGPA & score problem solving ability.



5. Conclusion

Apart from the academic record of a student, the psychological factors of the student also play a major role while predicting the best career(s) for a student. An expert system is designed and developed that provides an environment in which a student can solve crypt arithmetic puzzles at different levels.

Basing on the performance



of the student that is depicted by the score obtained, the system assesses the levels of the psychological factors of the student and builds a cognitive model of the student. The system finds suitable jobs for the student basing on the cognitive model

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