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TABLE OF CONTENT

PART 1: MATHEMATICS

	Page
STATISTICAL ANALYSIS ON THE EFFECTIVENESS OF SHORT-TERM PROGRAMS DURING COVID-19 PANDEMIC: IN THE CASE OF PROGRAM BIJAK SIFIR 2020 *Nazihah Safie, Syerrina Zakaria, Siti Madhihah Abdul Malik, Nur Baini Ismail, Azwani Alias Ruwaidiah Idris*	**1**
RADIATIVE CASSON FLUID OVER A SLIPPERY VERTICAL RIGA PLATE WITH VISCOUS DISSIPATION AND BUOYANCY EFFECTS *Siti Khuzaimah Soid, Khadijah Abdul Hamid, Ma Nuramalina Nasero, NurNajah Nabila Abdul Aziz*	**10**
GAUSSIAN INTEGER SOLUTIONS OF THE DIOPHANTINE EQUATION $x^4 + y^4 = z^3$ FOR $x \neq y$ *Shahrina Ismail, Kamel Ariffin Mohd Atan and Diego Sejas Viscarra*	**19**
A SEMI ANALYTICAL ITERATIVE METHOD FOR SOLVING THE EMDEN-FOWLER EQUATIONS *Mat Salim Selamat, Mohd Najir Tokachil, Noor Aqila Burhanddin, Ika Suzieana Murad and Nur Farhana Razali*	**28**
ROTATING FLOW OF A NANOFLUID PAST A NONLINEARLY SHRINKING SURFACE WITH FLUID SUCTION *Siti Nur Alwani Salleh, Norfifah Bachok and Nor Athirah Mohd Zin*	**36**
MODELING THE EFFECTIVENESS OF TEACHING BASIC NUMBERS THROUGH MINI TENNIS TRAINING USING MARKOV CHAIN *Rahela Abdul Rahim, Rahizam Abdul Rahim and Syahrul Ridhwan Morazuk*	**46**
PERFORMANCE OF MORTALITY RATES USING DEEP LEARNING APPROACH *Mohamad Hasif Azim and Saiful Izzuan Hussain*	**53**
UNSTEADY MHD CASSON FLUID FLOW IN A VERTICAL CYLINDER WITH POROSITY AND SLIP VELOCITY EFFECTS *Wan Faezah Wan Azmi, Ahmad Qushairi Mohamad, Lim Yeou Jiann and Sharidan Shafie*	**60**
DISJUNCTIVE PROGRAMMING - TABU SEARCH FOR JOB SHOP SCHEDULING PROBLEM *S. Z. Nordin, K.L. Wong, H.S. Pheng, H. F. S. Saipol and N.A.A. Husain*	**68**
FUZZY AHP AND ITS APPLICATION TO SUSTAINABLE ENERGY PLANNING DECISION PROBLEM *Liana Najib and Lazim Abdullah*	**78**
A CONSISTENCY TEST OF FUZZY ANALYTIC HIERARCHY PROCESS *Liana Najib and Lazim Abdullah*	**89**
FREE CONVECTION FLOW OF BRINKMAN TYPE FLUID THROUGH AN COSINE OSCILLATING PLATE *Siti Noramirah Ibrahim, Ahmad Qushairi Mohamad, Lim Yeou Jiann, Sharidan Shafie and Muhammad Najib Zakaria*	**98**

RADIATION EFFECT ON MHD FERROFLUID FLOW WITH RAMPED WALL TEMPERATURE AND ARBITRARY WALL SHEAR STRESS **106**
Nor Athirah Mohd Zin, Aaiza Gul, Siti Nur Alwani Salleh, Imran Ullah, Sharena Mohamad Isa, Lim Yeou Jiann and Sharidan Shafie

PART 2: STATISTICS

A REVIEW ON INDIVIDUAL RESERVING FOR NON-LIFE INSURANCE **117**
Kelly Chuah Khai Shin and Ang Siew Ling

STATISTICAL LEARNING OF AIR PASSENGER TRAFFIC AT THE MURTALA MUHAMMED INTERNATIONAL AIRPORT, NIGERIA **123**
Christopher Godwin Udomboso and Gabriel Olugbenga Ojo

ANALYSIS ON SMOKING CESSATION RATE AMONG PATIENTS IN HOSPITAL SULTAN ISMAIL, JOHOR **137**
Siti Mariam Norrulashikin, Ruzaini Zulhusni Puslan, Nur Arina Bazilah Kamisan and Siti Rohani Mohd Nor

EFFECT OF PARAMETERS ON THE COST OF MEMORY TYPE CHART **146**
Sakthiseswari Ganasan, You Huay Woon and Zainol Mustafa

EVALUATION OF PREDICTORS FOR THE DEVELOPMENT AND PROGRESSION OF DIABETIC RETINOPATHY AMONG DIABETES MELLITUS TYPE 2 PATIENTS **152**
Syafawati Ab Saad, Maz Jamilah Masnan, Karniza Khalid and Safwati Ibrahim

REGIONAL FREQUENCY ANALYSIS OF EXTREME PRECIPITATION IN PENINSULAR MALAYSIA **160**
Iszuanie Syafidza Che Ilias, Wan Zawiah Wan Zin and Abdul Aziz Jemain

EXPONENTIAL MODEL FOR SIMULATION DATA VIA MULTIPLE IMPUTATION IN THE PRESENT OF PARTLY INTERVAL-CENSORED DATA **173**
Salman Umer and Faiz Elfaki

THE FUTURE OF MALAYSIA'S AGRICULTURE SECTOR BY 2030 **181**
Thanusha Palmira Thangarajah and Suzilah Ismail

MODELLING MALAYSIAN GOLD PRICES USING BOX-JENKINS APPROACH **186**
Isnewati Ab Malek, Dewi Nur Farhani Radin Nor Azam, Dinie Syazwani Badrul Aidi and Nur Syafiqah Sharim

WATER DEMAND PREDICTION USING MACHINE LEARNING: A REVIEW **192**
Norashikin Nasaruddin, Shahida Farhan Zakaria, Afida Ahmad, Ahmad Zia Ul-Saufie and Norazian Mohamaed Noor

DETECTION OF DIFFERENTIAL ITEM FUNCTIONING FOR THE NINE-QUESTIONS DEPRESSION RATING SCALE FOR THAI NORTH DIALECT **201**
Suttipong Kawilapat, Benchlak Maneeton, Narong Maneeton, Sukon Prasitwattanaseree, Thoranin Kongsuk, Suwanna Arunpongpaisal, Jintana Leejongpermpool, Supattra Sukhawaha and Patrinee Traisathit

ACCELERATED FAILURE TIME (AFT) MODEL FOR SIMULATION PARTLY INTERVAL-CENSORED DATA **210**
Ibrahim El Feky and Faiz Elfaki

MODELING OF INFLUENCE FACTORS PERCENTAGE OF GOVERNMENTS' RICE RECIPIENT FAMILIES BASED ON THE BEST FOURIER SERIES ESTIMATOR **217**
Chaerobby Fakhri Fauzaan Purwoko, Ayuning Dwis Cahyasari, Netha Aliffia and M. Fariz Fadillah Mardianto

CLUSTERING OF DISTRICTS AND CITIES IN INDONESIA BASED ON POVERTY INDICATORS USING THE K-MEANS METHOD **225**
Khoirun Niswatin, Christopher Andreas, Putri Fardha Asa OktaviaHans and M. Fariz Fadilah Mardianto

ANALYSIS OF THE EFFECT OF HOAX NEWS DEVELOPMENT IN INDONESIA USING STRUCTURAL EQUATION MODELING-PARTIAL LEAST SQUARE **233**
Christopher Andreas, Sakinah Priandi, Antonio Nikolas Manuel Bonar Simamora and M. Fariz Fadillah Mardianto

A COMPARATIVE STUDY OF MOVING AVERAGE AND ARIMA MODEL IN FORECASTING GOLD PRICE **241**
Arif Luqman Bin Khairil Annuar, Hang See Pheng, Siti Rohani Binti Mohd Nor and Thoo Ai Chin

CONFIDENCE INTERVAL ESTIMATION USING BOOTSTRAPPING METHODS AND MAXIMUM LIKELIHOOD ESTIMATE **249**
Siti Fairus Mokhtar, Zahayu Md Yusof and Hasimah Sapiri

DISTANCE-BASED FEATURE SELECTION FOR LOW-LEVEL DATA FUSION OF SENSOR DATA **256**
M. J. Masnan, N. I. Maha3, A. Y. M. Shakaf, A. Zakaria, N. A. Rahim and N. Subari

BANKRUPTCY MODEL OF UK PUBLIC SALES AND MAINTENANCE MOTOR VEHICLES FIRMS **264**
Asmahani Nayan, Amirah Hazwani Abd Rahim, Siti Shuhada Ishak, Mohd Rijal Ilias and Abd Razak Ahmad

INVESTIGATING THE EFFECT OF DIFFERENT SAMPLING METHODS ON IMBALANCED DATASETS USING BANKRUPTCY PREDICTION MODEL **271**
Amirah Hazwani Abdul Rahim, Nurazlina Abdul Rashid, Abd-Razak Ahmad and Norin Rahayu Shamsuddin

INVESTMENT IN MALAYSIA: FORECASTING STOCK MARKET USING TIME SERIES ANALYSIS **278**
Nuzlinda Abdul Rahman, Chen Yi Kit, Kevin Pang, Fauhatuz Zahroh Shaik Abdullah and Nur Sofiah Izani

PART 3: COMPUTER SCIENCE & INFORMATION TECHNOLOGY

ANALYSIS OF THE PASSENGERS' LOYALTY AND SATISFACTION OF AIRASIA PASSENGERS USING CLASSIFICATION 291
Ee Jian Pei, Chong Pui Lin and Nabilah Filzah Mohd Radzuan

HARMONY SEARCH HYPER-HEURISTIC WITH DIFFERENT PITCH ADJUSTMENT OPERATOR FOR SCHEDULING PROBLEMS 299
Khairul Anwar, Mohammed A.Awadallah and Mohammed Azmi Al-Betar

A 1D EYE TISSUE MODEL TO MIMIC RETINAL BLOOD PERFUSION DURING RETINAL IMAGING PHOTOPLETHYSMOGRAPHY (IPPG) ASSESSMENT: A DIFFUSION APPROXIMATION – FINITE ELEMENT METHOD (FEM) APPROACH 307
Harnani Hassan, Sukreen Hana Herman, Zulfakri Mohamad, Sijung Hu and Vincent M. Dwyer

INFORMATION SECURITY CULTURE: A QUALITATIVE APPROACH ON MANAGEMENT SUPPORT 325
Qamarul Nazrin Harun, Mohamad Noorman Masrek, Muhamad Ismail Pahmi and Mohamad Mustaqim Junoh

APPLY MACHINE LEARNING TO PREDICT CARDIOVASCULAR RISK IN RURAL CLINICS FROM MEXICO 335
Misael Zambrano-de la Torre, Maximiliano Guzmán-Fernández, Claudia Sifuentes-Gallardo, Hamurabi Gamboa-Rosales, Huizilopoztli Luna-García, Ernesto Sandoval-García, Ramiro Esquivel-Felix and Héctor Durán-Muñoz

ASSESSING THE RELATIONSHIP BETWEEN STUDENTS' LEARNING STYLES AND MATHEMATICS CRITICAL THINKING ABILITY IN A 'CLUSTER SCHOOL' 343
Salimah Ahmad, Asyura Abd Nassir, Nor Habibah Tarmuji, Khairul Firhan Yusob and Nor Azizah Yacob

STUDENTS' LEISURE WEEKEND ACTIVITIES DURING MOVEMENT CONTROL ORDER: UiTM PAHANG SHARING EXPERIENCE 351
Syafiza Saila Samsudin, Noor Izyan Mohamad Adnan, Nik Muhammad Farhan Hakim Nik Badrul Alam, Siti Rosiah Mohamed and Nazihah Ismail

DYNAMICS SIMULATION APPROACH IN MODEL DEVELOPMENT OF UNSOLD NEW RESIDENTIAL HOUSING IN JOHOR 363
Lok Lee Wen and Hasimah Sapiri

WORD PROBLEM SOLVING SKILLS AS DETERMINANT OF MATHEMATICS PERFORMANCE FOR NON-MATH MAJOR STUDENTS 371
Shahida Farhan Zakaria, Norashikin Nasaruddin, Mas Aida Abd Rahim, Fazillah Bosli and Kor Liew Kee

ANALYSIS REVIEW ON CHALLENGES AND SOLUTIONS TO COMPUTER PROGRAMMING TEACHING AND LEARNING 378
Noor Hasnita Abdul Talib and Jasmin Ilyani Ahmad

PART 4: OTHERS

ANALYSIS OF CLAIM RATIO, RISK-BASED CAPITAL AND VALUE-ADDED INTELLECTUAL CAPITAL: A COMPARISON BETWEEN FAMILY AND GENERAL TAKAFUL OPERATORS IN MALAYSIA **387**
Nur Amalina Syafiqa Kamaruddin, Norizarina Ishak, Siti Raihana Hamzah, Nurfadhlina Abdul Halim and Ahmad Fadhly Nurullah Rasade

THE IMPACT OF GEOMAGNETIC STORMS ON THE OCCURRENCES OF EARTHQUAKES FROM 1994 TO 2017 USING THE GENERALIZED LINEAR MIXED MODELS **396**
N. A. Mohamed, N. H. Ismail, N. S. Majid and N. Ahmad

BIBLIOMETRIC ANALYSIS ON BITCOIN 2015-2020 **405**
Nurazlina Abdul Rashid, Fazillah Bosli, Amirah Hazwani Abdul Rahim, Kartini Kasim and Fathiyah Ahmad@Ahmad Jali

GENDER DIFFERENCE IN EATING AND DIETARY HABITS AMONG UNIVERSITY STUDENTS **413**
Fazillah Bosli, Siti Fairus Mokhtar, Noor Hafizah Zainal Aznam, Juaini Jamaludin and Wan Siti Esah Che Hussain

MATHEMATICS ANXIETY: A BIBLIOMETRIX ANALYSIS **420**
Kartini Kasim, Hamidah Muhd Irpan, Noorazilah Ibrahim, Nurazlina Abdul Rashid and Anis Mardiana Ahmad

PREDICTION OF BIOCHEMICAL OXYGEN DEMAND IN MEXICAN SURFACE WATERS USING MACHINE LEARNING **428**
Maximiliano Guzmán-Fernández, Misael Zambrano-de la Torre, Claudia Sifuentes-Gallardo, Oscar Cruz-Dominguez, Carlos Bautista-Capetillo, Juan Badillo-de Loera, Efrén González Ramírez and Héctor Durán-Muñoz

MODELING THE EFFECTIVENESS OF TEACHING BASIC NUMBERS THROUGH MINI TENNIS TRAINING USING MARKOV CHAIN

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Mathematics is often considered a difficult and boring subject for most children because its use in daily activities is not given proper emphasis. The activity of counting numbers in ascending order is the basis of learning mathematics. While the activity of playing through physical movement is the most popular activity by children. Therefore, an approach should be taken to build a relationship between mathematics learning and physical activity games so that children can gain skills in both areas simultaneously and can save time, energy and human resource. This study pioneered the technique of learning to make basic number calculations for children through a tennis mini game called *AB-kiRA*. To measure the effectiveness of this technique a Markov chain model was developed to analyze the performance of trainees in making basic number calculations during mini tennis training. Data from 150 training trials were used to generate the transition matrix. Next a calculation to obtain the probability of the equilibrium state is performed. The results show that the trainees will be able to master the basic number counting skills after 10 attempts are made through the shot of the ball made by the trainee. This information can be the basis of a guide for training other mini tennis trainee children in mastering basic number counting skills.

***Keywords*:** Mini Tennis, Markov Chain, Physical Activity

1. Introduction

Most researchers agree the use of games can improve the achievement of mathematics subjects among children (Radford, 2020; Reikeras, 2020; Tsamir et al., 2020). Tsamir et al. (2020) stated that games are a positive method in improving achievement. According to them, children who are given the opportunity to play have a clear purpose, use materials to solve problems and require action to achieve goals, give children opportunities to relate play materials and provide space for children to imagine. The study of Tirosh et al., (2020) use the effects of training and transfer the executive function of preschool children, they found that playing repetitive games can improve the memory of working children. Tennis is a sport that requires repetitive shot practice. Therefore, this study chooses the sport of tennis as a game related to this theory in addition to the researcher's expertise in this field of play.

Tennis in Malaysia is one of the rare individual sports for children between the ages of 6-12. Among the main reasons because it is a sport that is difficult to learn, takes time and a relatively long commitment (1-2 years) to acquire the necessary playing skills. Furthermore, tennis is always played as an adult game. The average child exposed to tennis is from parents who are actively involved or those who have a deep interest in the sport. Now tennis has been innovated so that the children can acquire the basics of playing skills in a short period of time as early as 2-3 months. This effort was made by modifying tennis balls to be slower in movement and tennis courts for children to be smaller in size. Changes to the structure of this tennis sport to children are called mini tennis.

1.1 AB-kiRA

Since play activities in the teaching and learning process in school can benefit children in terms of development, learning and motivation as well as fun to play, the researcher plans to introduce the technique of counting basic numbers among children through a mini tennis game called *AB-kiRA* . This technique can be a guide and guidance to instructors who will teach the basics of math to children through tennis game practice. *ABRA* is the abbreviation of the name of the founder of the children's tennis game training technique, namely Encik Abdul Rahim Bin Ismail, which was founded around the 1960s in Jitra, Kedah. The techniques practiced by him have proven successful in producing human beings with high self-esteem. These techniques will be absorbed according to the suitability of the current generation, technology and education.

1.2 Markov Chain Model For *AB-kiRA* Experiments

Markov chains are probability-based mathematical models. The principle of the Markov chain approach is that the probability for an event to occur on the $n+1$ th attempt is dependent on the probability of the event occurring on the n th attempt and not on previous attempts (Rahim & Jamaludin, 2017). Markov chains are often used in the improvement of a policy such as in (Rahim, et al., 2016), evaluating human resource performance (Rahim, et al., 2015) and forecasting (Rahim, et al., 2013). This study attempts to pioneer the use of Markov chains in evaluating achievement performance in the ability to master the AB-kiRA number base.

2. Methodology

One hundred and fifty test were performed with the trainee hitting the ball 30 times while making the count. The experiments were conducted 150 times over 4 months. Trainees will be sent the ball to be hit in the form of practice and asked to count up to 30 counts. Correct counts are considered successful and incorrect counts are considered failed. The results are recorded as in Table 1 below.

Table 1: Transition Matrix of Observation on Trainee Performs Counting During Training.

		Count at $n = i + 1$		
		Pass (P*)	Fail (F)	Total
Count at $n = i$	Pass (P*)	100	23	123
	Fail (F)	23	4	27
	Total	123	27	150

From Table 1, the trainee who managed to make the count correctly at time $n = i + 1$ knowing he also managed to make the count correctly at time $n = i$ was 100 and 23 times made the wrong count knowing the previous test managed to make the count correctly. The trainee managed to make the count correctly known he failed to make the count correctly before was 23 times and the trainee failed to make the count correctly known before also he failed to make the count correctly was 4 times. Markov chains are only available in predicting conditional probabilities. Therefore all conditional probabilities need to be calculated. After obtaining the conditional probabilities, a transition matrix should be formed to produce a Markov chain model.

For example, with the original matrix input, the results for 10 attempts to make a number count can be predicted. Next the probability of the trainee pattern being able to make a number count correctly in 10 trials can be expected. However, to achieve a probability equilibrium, a steadystate vector must be determined. To determine the result of whether the 10th attempt has reached equilibrium, the state vector on the 10th attempt needs to be compared with the steadystate equilibrium vector. Once the transition matrix is obtained as in Table 1, the conditional probabilities are obtained as the following formula:

$$\mathrm{P}(\text{Count at } n = i{+}1 \mid \text{Count at } n = i) = \frac{n(\text{Count at } n = i{+}1 \cap \text{Count at } n = i)}{n(\text{Count at } n = i)}$$

Where $n = i$ is event at time i.

Thus, the calculation of the conditional probabilities is as follows:

$$\mathrm{P}(\mathrm{P}^* \mid \mathrm{F}) = \frac{n(\mathrm{P}^* \cap \mathrm{F})}{n(\mathrm{P}^*)} \qquad \mathrm{P}(\mathrm{F} \mid \mathrm{P}) = \frac{n(\mathrm{F} \cap \mathrm{P}^*)}{n(\mathrm{P}^*)}$$

$$= \frac{100}{123} \qquad = \frac{23}{123}$$

$$= 0.813008 \qquad = 0.186992$$

$$\mathrm{P}(\mathrm{P}^* \mid \mathrm{F}) = \frac{n(\mathrm{P}^* \cap \mathrm{F})}{n(\mathrm{F})} \qquad \mathrm{P}(\mathrm{P}^* \mid \mathrm{F}) = \frac{n(\mathrm{F} \cap \mathrm{F})}{n(\mathrm{F})}$$

$$= \frac{23}{27} \qquad = \frac{4}{27}$$

$$= 0.851852 \qquad = 0.148148$$

The transition matrix as in Table 2 below.

Table 2: Transition Probability Matrix of Observation on Trainee Performs Counting During Training.

		Count at $n = i + 1$		
		Pass (P*)	Fail (F)	Total
Count at $n = i$	Pass (P*)	0.813008	0.186992	1
	Fail (F)	0.851852	0.148148	1

The result can be written in the form of the Tansition Probabillity Matrice,

$$\boldsymbol{T} = \begin{bmatrix} 0.813008 & 0.186992 \\ 0.851852 & 0.148148 \end{bmatrix} \tag{1}$$

2.1 Equilibrium State

A steady state is a state where we can anticipate on the number of attempts to how many trainees will be able to master the skill of counting in the count of 30 correctly. The determination of trials at this steady state is important as a guide to be an indication of the minimum trials that need to be done during training in order to produce the skills desired by the trainee. A steadystate is obtained from a transition matrix formed in Table 2. The transition matrix is used to predict the k-state vector, X_k represents the probability of the trainee successfully making the calculation correctly on the k-th attempt which can be determined as below

$$\begin{aligned} \boldsymbol{X}_k &= \boldsymbol{X}_{k-1}\boldsymbol{T} \\ &= \boldsymbol{X}_{k-2}\boldsymbol{T}^2 \\ &= \boldsymbol{X}_{k-3}\boldsymbol{T}^3 \\ &\vdots \\ &= \boldsymbol{X}_{k-k}\boldsymbol{T}^k \\ \therefore \boldsymbol{X}_k &= \boldsymbol{X}_0\boldsymbol{T}^k \end{aligned}$$

Next,by using the Microsoft Excel, the results for 10 training trials with counts were predicted. Thus, the probability pattern of successfully making a calculation correctly can be plotted on a line graph. The equilibrium probability is obtained when the fixed state vector does not change its value on each subsequent attempt. Thus the steadystate vector, $\boldsymbol{Q}$ can be calculated using the following formula:

$$\boldsymbol{QT} = \boldsymbol{Q}$$

$$\boldsymbol{Q} = [q_1 \quad q_2]$$

The results for the trainee's 10th attempt to make the count correctly, X_{10} were compared with $\boldsymbol{Q}$ to test whether the probability of making the count correctly on the 10th attempt had reached equilibrium.

3. Results And Analysis

By using the original state vector, $x_0 = [0\ 1]$ and assuming that the trainee failed to make the count correctly on the first attempt, the probability of the trainee succeeding or failing to make the count correctly on the 6 training attempts is shown as in Table 3 below.

Table 3: The probability of a trainee succeeding or failing to make a calculation correctly.

	$P(P)$	$P(F)$
x_1	0	1
x_2	0.851852	0.148148
x_3	0.818763	0.181237
x_4	0.820048	0.179952
x_5	0.819998	0.180002
x_6	0.82	0.18
x_7	0.82	0.18
x_8	0.82	0.18
x_9	0.82	0.18
x_{10}	0.82	0.18

Next, the probability of the trainee successfully making the count correctly on each attempt is exhibited as Figure 2 below.

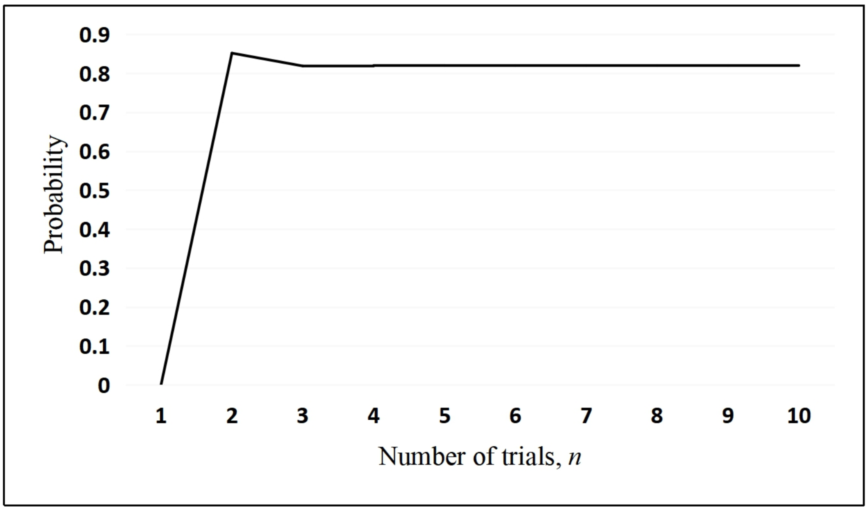

Figure 2. The probability of the trainee successfully making the count correctly on the n-th attempt.

The results showed that the probability of the trainee successfully making the count correctly focused to 0.82 as the number of attempts increased. However, the equilibrium probability for the trainee to successfully make the calculation correctly is reached when

$$\boldsymbol{QT} = \boldsymbol{Q}$$
$$\boldsymbol{QT} - \boldsymbol{Q} = \boldsymbol{0}, \text{ where } \boldsymbol{Q} = \boldsymbol{QI}$$
$$\boldsymbol{Q}(\boldsymbol{T} - \boldsymbol{I}) = \boldsymbol{0}$$

$$[q_1 \quad q_2]\left(\begin{bmatrix}0.813008 & 0.186992\\0.851852 & 0.148148\end{bmatrix} - \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}\right) = \begin{bmatrix}0 & 0\\0 & 0\end{bmatrix}$$

$$[q_1 \quad q_2]\begin{bmatrix}-0.186992 & 0.186992\\0.851852 & -0.851852\end{bmatrix} = 0$$

Since the system of equations has a trivial solution, the values of q_1 and q_2 are equal to 0. However, the steadystate vector must have the sum of all elements 1, therefore the trivial solution is rejected. In order to find another solution, another constraint needs to be added to the system of equations i.e.

$$q_1 + q_2 = 1$$

Finally the following result is obtained;

$$\boldsymbol{Q} = [0.82 \quad 0.18]$$

This means that the probability of the trainee successfully making the count correctly is stable at 0.82 after several training attempts are conducted. While the probability of trainees failing to make the count correctly was stable at 0.18 after several training attempts were conducted. It is clear that x_6 is equal to $\boldsymbol{Q}$, therefore, we can conclude that the chance for the trainee to successfully make the count correctly during training is stable after 6 training attempts are performed.

4. Conclusions

Mini tennis exercises that require repeated shots of the ball can be used to train children to master basic number counting skills. Indirectly, such training can cultivate children to master both academic and sports skills at the same time. Information that can be used as a guide to teachers in realizing this effort is important. The *AB-kiRa* Markov chain model developed in this study predicts the minimum number of shot-while-counting training attempts required by trainees to master a set of ascending number counting skills. The results of this study showed that out of 100 tests conducted, there were 82 times where the trainee managed to make 30 counts correctly while 18 of themwere failed. This model has the potential to be expanded to other training skills where consistency is a key element in the training studied.

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