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Table of Contents

Mathematical elements about logistic solution during serving of containers for communal waste – Study of case about Municipality of Bitola

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Abstract

This paper represents a picture of one situation that is present in all cities of Republic of Macedonia. Concretely it refers about a situation of collecting a communal waste. In this paper it was reviewed the time of serving per container in the town of Bitola at every day relation for collection of the communal waste with application of adequate mathematical methodology. This research of the phenomenon about collection of the communal waste has a task to allow application of the mathematical model based on real and realistic data that will lead toward one real and maintainable solution in future. At the same time this paper with these mathematical relations placed in this way will be able to be applied also in other cases with similar specifics as Bitola.

No matter of the fact that separate types of the studies significantly differ among themselves, anyway it is necessary to define mutual elements that will represent one common approach during performing of any of the studies. In this case it is important defined the clear aim, and that is exact and relevant data about the collection of the container waste in Bitola. Then on a base of real data, together with the already existing data of the Communal enterprise Komunalec – Communal Hygiene, a certain statistical calculations will be done and will approach toward defining of concrete conclusion, which will refer to an offer of maintainable logistic solution that will offer better alternatives in future.

Key words: Bitola, communal waste, serving of containers, logistic solution, mathematical elements.

1. Introduction

The necessity of organized collection of the communal waste should be priority of each town and each municipality. This phenomenon of organized collection of the communal waste is regulated in dependence with the level of development of each state. In the world this problem represents one of the basic communal issues that at the same time reflect also the quality of living, because each town authority invests as much as possible in this field, and as a return of that the citizens get more pleasant conditions for living.

Solving of this communal issue on an organized way requires one great painstaking work in which all the phases that follow this phenomenon should be comprised. Here it should not separate any procedure connected with this organization because interrupting of one whichever phase, and in whichever moment could lead to paralyzing of one town surrounding which is illegal. And the fact itself that the town functions with this issue, this additionally makes it more priority for all citizens with no division i.e. literally for everybody.

In this paper is comprised the issue with collection of the container waste at the level of the town of Bitola, with aim to optimize the periods of serving per container (separately) in order for better planning and organization of the collection of the communal waste. For adequate mathematical and statistical analysis it was necessary first of all to perceive the factual situation and to gather the relevant data. After these situations and indicators were clearly emphasized then it could in accordance with the global experiences and on already reviewed and the factual situation it could be offered maintainable logistical solution with which every citizen of the town of Bitola will have benefits, and the offered positive improvements will have sustainable application also in other cases.

2. Subject and aim of the paper

Placement and defining of the **subject** and aim of the concrete paper is in close connection with

the observed issue, although individual types of studies differentiate among themselves, anyway mutual elements exist there, which are unique for the phenomenon of collecting of communal waste. **Subject of this paper is analysis of the collecting of the communal waste in the town of Bitola.** At the same time it represents product of the common aims of the community for solving of the adequate issue so as to create surrounding that will be distinguished with high quality of living, and at the same time it will be economically justified. The concrete issue refers to the collection of the container communal waste on the every days relation and the possibility of noticing of the anomalies, and with that also the implementation of certain changes in regard of optimization, first of all on the time of service which further more would drag also economic benefit and also raising of the living quality.

What concerns the aims, the same were mentioned above but anyway it should be pointed out once again that the concept of creation of maintainable living surrounding all by itself imposes the same aims. **In this concrete case the aims in this paper consist the common frame for preparation, valuation and testing of the alternative maintainable logistic solutions in the future.**

3. Data about the town of Bitola

First written documents about the town of Bitola[1] dated since the fourth century when it is believed that Filip 2 had formed the town of Heraclea Linkestis whose excavations now are found in the close nearness.

Bitola is the greatest city center in the fertile and the biggest Macedonian valley Pelagonija which is part of the Balkan Peninsula and second city by size in Republic of Macedonia.

According to the last census from 2002 year, in Bitola live 86 408 citizens[2], while with the new territorial division of 2005 year, toward this figure are joined also the rural municipalities Bistrica, Kukurechani and Capari with which the number of the citizens is enlarged for additional 15 percent. The municipality of Bitola is extended on area of 792,53 m^3 . On the basis of the data from 2005 year from the services of the public communal enterprise – Komunalec of Bitola, the quantities of collected and transported communal waste for the Municipality of Bitola amount from 300 – 350 tons per month and is disposed on a waste dump 17 kilometers far from the town[3]. The communal waste is collected in a non-systematic way that financially burdens the enterprise itself, and with that the citizens also get lower level of service.

From the data above, and also from the administrative point of view, the town of Bitola is the seat of the Municipality of Bitola, and also main regional center for the southwest region of Republic of Macedonia. This that is quoted about Bitola justifies the research that is carried out for the needs of this paper, and each mathematical support, each scientific research in great percent makes it maintainable.

4. Methodology of data collecting

In this paper the methodology that will be applied is based on direct collection of data at field with application of scientific methods: ***analysis, synthesis, classification, abstraction, concretization, generalization, description and comparison.*** As a need of counting and perceiving of the situation, and also as a need for somewhat changes it always goes to the most loaded relation, in this case that was the every days relation. That every days relation is the following: (Beside the river Dragor -2, The wooden bridge – 4, Hamdi – 1, The tower at Ajcho – 1, The Coffee bar Solun – 2, Bingo Joker – 1, The Post office and Stopanska bank -3, Magnolia -2, Ikebana – 1, MIA – 1, Javor – 6, Ivan Milutinovich part – 8, Culture Dom – 2, Old Hospital – 5, Handball playground – 3, Settlement Karposh and Klanica – 12, Prilepska – 32, Boris Basterot – 6, Shiroka plus part of Prilepska – 12). The figures indicate how big is the number of considered containers, and the every days relation comprises almost 20% of the city territory.

This was determined by previously thorough analysis of the responsible persons in the enterprise and therefore the data refer to this region where the necessity for changes is unavoidability. Therefore this phase of the research of the com-

1 http://www.bitola.gov.mk
2 http://www.stat.gov.mk
3 http://www.komunalecbt.com.mk

munal issue in Bitola would be in this concrete part which by the help of counting of the situation of that region in a market day and the fulfilled containers with communal waste is great, and each proposition and method for solving the issue is justified.

The method of gathering in this phase comprised making of one picture of collecting a container communal waste in Bitola. So as to realize this procedure, preparations were necessary, that comprise:

- Request from the responsible persons about authorization of the procedure for collection of data,
- Small preparation and provision of two stop watches which were base for the correctness of the data,
- Preparation of the application on which the data were collected and other small preparations that in the text were stressed (represented down in the paper).

The counting was done on 07 05 2012 year by previously quoted relation. The collection of the data due to greater clearness is represented in tabular form, represented in the continuation of this paper. Important data that were base of the collected data were the following:

- To the counting three workers and the driver of the vehicle were present,
- The number of fulfilled containers was the following and it amounted 103
- The counting was performed with Vehicle Iveko big with 16 m.
- The counting started at 07 00 and ended at 12 50 hour

The counting started from the enterprise itself comprising the following preparation phases that follow each start of the process for collection of garbage. These preparation phases were the following:

- Preparation of the driver with the responsible person and signature for start of the work – 2 minutes
- Check of oil – 5 minutes
- Check of the fluids in the vehicles mechanisms – 5 minutes
- Preparation with the workers – 5 minutes

After the whole preparation procedure was ok then is approached to the procedure of going to the first container, and arriving to the first container was for about three minutes which means the counting itself of the collection of the container communal waste started at 07 20 hours and with that started the counting of separate phases and recording of the times in adequate application that has the following appearance in figure number 1, table number 1 and table number 3.

The methodology that was applied during collection of the data was of that nature so as to provide data that will be relevant and precise. But anyway not to apply some expensive methods, and to have the issue in data form and possibility of data processing. With the application of the mathematical methods and the adequate simulation in future there will be possibility to propose maintainable logistical solutions that will refer to improvement of the picture in the town of Bitola from aspect of this phenomenon. These logistical solutions will be supplemented with elements of the scientific methods that are applied during preparation of concrete studies in practice [1]. Also with this it will be allowed also comparative analysis with the papers of the global literature [2], [3], and also the expert literature in global frames [4], [5], and at us [6], supported with legal regulative in Republic of Macedonia[4].

Therefore this paper should represent one clear base on which in future should bring concrete solutions that will be valid from three aspects: collection and analysis of data, mathematical and statistical calculations, and the offer of conclusions that in future would be solid logistical solutions.

5. Tabular presentation of the collected data

In the following text are represented data in tabular form that refer on the following. In the table number 2 is given a tabular form of the area that represents every days relation for collection of container communal waste with additional hand collection of the communal waste for each day separately as it is represented in the table.

At the following table number 1 are represented data that were collected by the counting persons with help of two synchronized stop watches,

4 http:// www.pravo.gov.mk

Table 1. The phases with individual times of service per each container separately [4], [5].
**The times in the table are expressed in seconds.*

Phases	Number of Container																		
	01	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Carrying	40	30	13	10	25	20	13	21	26	8	6	6	15	3	4	90	45	5	10
Hook on	10	10	12	12	10	10	7	7	24	12	11	4	5	7	6	10	8	18	8
Lifting	10	10	12	12	8	8	35	55	12	15	15	25	25	24	15	12	22	45	25
Emptying	35	40	50	20	40	90	7	10	89	8	8	10	5	5	4	3	3	4	4
Taking down	10	10	8	10	12	9	4	5	10	4	8	4	5	5	8	3	3	3	5
Returning	10	10	7	10	10	14	10	5	10	6	10	10	5	6	4	35	35	5	3
Phases	**Number of Container**																		
	20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
Carrying	2	2	2	18	2	2	5	4	3	3	3	4	5	5	3	3	5	5	40
Hook on	7	8	6	8	6	7	6	7	6	6	6	8	7	6	6	8	5	8	7
Lifting	25	34	42	50	28	48	25	21	32	18	26	41	22	35	22	18	20	19	53
Emptying	5	5	4	4	3	4	2	2	18	3	4	4	4	4	4	4	4	5	6
Taking down	5	5	3	3	3	4	2	3	3	3	5	3	3	3	5	5	4	5	2
Returning	3	3	4	13	3	6	5	1	2	3	4	4	2	5	3	3	3	2	15
Phases	**Number of Container**																		
	39	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**
Carrying	60	25	45	10	10	10	6	6	4	3	3	3	6	4	4	4	5	6	5
Hook on	15	12	8	8	7	6	6	8	8	8	8	8	4	8	8	9	9	9	8
Lifting	49	53	42	36	32	39	45	50	52	49	47	47	48	35	46	46	61	45	50
Emptying	6	7	5	4	4	4	6	6	4	6	6	6	5	5	5	5	5	5	5
Taking down	2	5	3	3	2	3	2	2	2	3	3	3	4	4	3	2	3	3	4
Returning	5	2	10	5	5	2	2	2	3	3	3	3	2	2	2	2	2	5	2
Phases	**Number of Container**																		
	58	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**
Carrying	6	6	7	8	8	8	8	6	6	6	7	5	5	7	6	7	6	5	10
Hook on	8	8	7	8	8	9	9	9	9	7	6	7	7	9	10	11	8	7	2
Lifting	42	16	16	25	25	24	26	24	18	15	15	19	27	33	34	18	19	107	26
Emptying	5	5	5	5	4	4	4	4	4	4	4	4	5	5	5	4	4	4	8
Taking down	4	4	4	3	3	4	4	4	4	4	4	3	3	4	3	3	4	4	5
Returning	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	3
Phases	**Number of Container**																		
	77	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**
Carrying	10	4	5	90	75	75	4	4	4	6	4	2	2	4	4	4	4	4	6
Hook on	2	7	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	11
Lifting	24	23	21	35	94	86	24	24	28	26	26	16	46	48	56	26	30	30	35
Emptying	4	4	4	6	6	6	6	6	11	4	4	4	4	4	4	6	6	6	7
Taking down	5	5	5	8	14	71	9	8	9	6	6	6	6	6	6	6	8	9	7
Returning	3	2	2	12	12	12	2	2	2	2	2	2	2	2	2	2	5	5	6
Phases	**Number of Container**																		
	96	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**
Carrying	5	5	5	5	10	10	10	10											
Hook on	9	7	16	16	10	10	8	9											
Lifting	40	42	60	40	49	48	47	56											
Emptying	16	12	8	9	10	9	9	9											
Taking down	3	3	4	5	8	7	6	6											
Returning	5	5	5	5	5	4	5	5											

and it refers to individual times for serving of each container separately.

So as to perform simulation of the service, necessary were also the total times of service per container which due to better clearness also were given in the table number 3. That table number 3 is the following.

Times of service, mathematical calculations and obtained results for each individual cycle and about the total time of service per container and that is: carrying of the container to the vehicle, hooking the container to the vehicle, lifting the container, emptying the container, taking down the container from the vehicle, returning the container to the place

Table 2. Appearance of every days relation for collection of the communal waste in Bitola

Monday	Tuesday	Wednesday	Thursday	Friday
Every day Relation	Every day Relation	Every day Relation	Every day Relation	Every day Relation
The chemical	Prilepska	Kumrovec	The chemical	Prilepska
E. Kardelj (part)	Old Hospital	P. Ilkovski	E. Kardelj (part)	Old Hospital
Karposh	B. Basterot	K. Chulakovski	Karposh	B. Basterot
I.Milutinovich	M. Gorki	P. Mircheva	I. Milutinovich	M. Gorki
N.N. Borche	Vrpolje	K. Dolovski	N.N. Borche	Vrpolje
	V. Palagich	Gj.Zekovski		V. Palagich
		A.Zdravevski		
		M.Vrchakovski		

Table 3. Total time of service per container [6].

Number of Container	Time of service (s)	Number of Container	Time of service (s)	Number of Container	Time of service (s)	Number of Container	Time of service (s)
1	115	27	38	53	68	79	45
2	110	28	64	54	68	80	159
3	102	29	36	55	85	81	209
4	74	30	48	56	73	82	258
5	105	31	64	57	74	83	53
6	151	32	43	58	67	84	52
7	76	33	58	59	41	85	62
8	103	34	43	60	42	86	52
9	171	35	41	61	51	87	51
10	53	36	45	62	50	88	39
11	58	37	44	63	51	89	69
12	59	38	123	64	53	90	73
13	60	39	137	65	49	91	81
14	50	40	104	66	43	92	53
15	41	41	113	67	39	93	62
16	153	42	66	68	38	94	63
17	116	43	60	69	40	95	72
18	80	44	64	70	49	96	78
19	55	45	67	71	60	97	74
20	47	46	74	72	60	98	98
21	57	47	73	73	45	99	80
22	61	48	72	74	44	100	92
23	96	49	70	75	129	101	88
24	45	50	70	76	54	102	85
25	71	51	69	77	48	103	95
26	45	52	58	78	45		

where it is positioned and the total time of service per each container. That is represented from table number four to table number 4.

***I CYCLE*: Carrying** (Comprises carrying of the container from the place where it is positioned to the vehicle with which the communal waste is collected).

The calculations about carrying cycle are the following

$$\min = 2; \quad \max = 90 \quad d = \frac{\min - \max}{N} = 8$$

$$x_o = 46 \qquad N = 103$$

$$\bar{x} = \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i + x_o = 12{,}6$$

$$\overline{M}_e = L + d \cdot \frac{\frac{N}{2} - (f_1 + f_2 + \ldots\ldots + f_k)}{f_{k+1}} = /$$

There is not arithmetical medium, Medijana.

There is not, because geometrically viewed the histogram could not be divided in two equal parts, and because of that if it should exist it should be found in the first interval, which mathematically viewed that is not possible (it should exist previous and following interval).

$$\overline{M_o} = L + d \cdot \frac{\Delta 1}{\Delta 1 + \Delta 2} = 6{,}42$$

$$s^2 = \frac{d^2}{N} \cdot \left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N} \cdot \left(\sum_{i=1}^{N} f_i t_i \right)^2 \right] = 245{,}37$$

$$s = 16$$

$$\overline{K_v} = \frac{s}{x} \cdot 100(\%) = 126{,}89\%$$

$$\overline{\mu_3} = \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 - 3 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 2 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^3 = 13180{,}3$$

$$\overline{\mu_4} = \frac{d^4}{N} \cdot \sum_{i=1}^{N} f_i t_i^4 - 4 \cdot \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 6 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^2 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 - 3 \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^4 = 919335{,}7$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu}_3}{s^3} = 3{,}2$$

II CYCLE: Hook on (Comprises hooking on of already brought container to the vehicle with which the communal waste is collected).

The calculations about the hooking on cycle, are the following

$$\min=2 ; \quad \max=24 \quad d = \frac{\min - \max}{N} = 2$$

$$x_0=13 \qquad N=103$$

Table 4. The cycle of carrying the container to the vehicle [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
2-10	6	73	-5	-365	1825	-9125	45625
10-18	14	14	-4	-64	224	-896	3584
18-26	22	5	-3	-15	45	-135	405
26-34	30	2	-2	-4	8	-16	32
34-42	38	2	-1	-2	2	-2	2
42-50	**46**	2	0	0	0	0	0
50-58	54	0	1	0	0	0	0
58-66	62	1	2	2	4	8	16
66-74	70	0	3	0	0	0	0
74-82	78	2	4	8	32	128	512
82-90	86	2	5	10	50	250	1250
$\sum$		103		-430	2190	-9788	51426

Table 5. The cycle of hooking on, of the container to the vehicle [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
2-4	3	4	-5	-20	100	-500	2500
4-6	5	14	-4	-56	224	-896	3584
6-8	7	47	-3	-141	423	-1269	3867
8-10	9	26	-2	-52	104	-208	416
10-12	11	7	-1	-7	7	-7	7
12-14	**13**	0	0	0	0	0	0
14-16	15	3	1	3	3	3	3
16-18	17	1	2	2	4	8	16
18-20	19	0	3	3	9	27	81
20-22	21	0	4	4	16	64	256
22-24	23	1	5	5	25	125	625
$\sum$		103		-259	915	-2653	11295

Table 6. The Cycle of lifting the container [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
8-17	12.5	16	-5	-80	400	-2000	10000
17-26	21.5	33	-4	-132	528	-2112	8448
26-35	30.5	15	-3	-45	135	-405	1215
35-44	39.5	9	-2	-18	36	-72	144
44-53	48.5	22	-1	-22	22	-22	22
53-62	**57.5**	5	0	0	0	0	0
62-71	66.5	0	1	0	0	0	0
71-80	75.5	0	2	0	0	0	0
80-89	84.5	1	3	3	9	27	81
89-98	93.5	1	4	4	16	64	256
98-107	102.5	1	5	5	25	125	625
$\sum$		103		-285	1171	-4395	20791

$$\bar{x} = \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i + x_o = 7{,}8$$

$$\overline{M_e} = L + d \cdot \frac{\frac{N}{2} - (f_1 + f_2 + \ldots\ldots + f_k)}{f_{k+1}} = 7.43$$

$$\overline{M_o} = L + d \cdot \frac{\Delta 1}{\Delta 1 + \Delta 2} = 7{,}2$$

$$s^2 = \frac{d^2}{N} \cdot \left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N} \cdot \left(\sum_{i=1}^{N} f_i t_i \right)^2 \right] = 10{,}24$$

$$s = 3{,}2$$

$$\overline{K_v} = \frac{s}{\bar{x}} \cdot 100(\%) = 41{,}0\%$$

$$\overline{\mu_3} = \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 - 3 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 2 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^3 = 75{,}64$$

$$\overline{\mu_4} = \frac{d^4}{N} \cdot \sum_{i=1}^{N} f_i t_i^4 - 4 \cdot \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 6 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^2 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 - 3 \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^4 = 1081{,}7$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu_3}}{s^3} = 2{,}31$$

III CYCLE: Lifting (Comprises lifting of already hooked on container to the vehicle with which the communal waste is collected).

The calculations about the lifting cycle, are the following

$$\text{min}=8;\quad \text{max}=107\quad d=\frac{\text{min}-\text{max}}{N}=9$$

$$x_0=57,5\qquad N=103$$

$$\bar{x}=\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i+x_o=32,6$$

$$\overline{M_e}=L+d\cdot\frac{\frac{N}{2}-(f_1+f_2+.....+f_k)}{f_{k+1}}=27,5$$

$$\overline{M_o}=L+d\cdot\frac{\Delta 1}{\Delta 1+\Delta 2}=21,37$$

$$s^2=\frac{d^2}{N}\cdot\left[\sum_{i=1}^{N}f_it_i^2-\frac{1}{N}\cdot\left(\sum_{i=1}^{N}f_it_i\right)^2\right]=300,7$$

$$s=17,34$$

$$\overline{K_v}=\frac{s}{x}\cdot 100(\%)=53,19\%$$

$$\overline{\mu_3}=\frac{d^3}{N}\cdot\sum_{i=1}^{N}f_it_i^3-3\cdot\frac{d^2}{N}\cdot\sum_{i=1}^{N}f_it_i^2\cdot\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i+$$

$$+2\cdot\left(\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i\right)^3=6807,1$$

$$\overline{\mu_4}=\frac{d^4}{N}\cdot\sum_{i=1}^{N}f_it_i^4-4\cdot\frac{d^3}{N}\cdot\sum_{i=1}^{N}f_it_i^3\cdot\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i+$$

$$+6\cdot\left(\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i\right)^2\cdot\frac{d^2}{N}\cdot\sum_{i=1}^{N}f_it_i^2-3\left(\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i\right)^4=1498712,5$$

Coefficient of asymmetry:

$$K_A=\frac{\overline{\mu_3}}{s^3}=1,31$$

IV CYCLE: Emptying (Comprises complete emptying of the container from the vehicle with which the communal waste is collected).

The calculations about the emptying cycle, are the following

$$\text{min}=2;\quad \text{max}=90\quad d=\frac{\text{min}-\text{max}}{N}=8$$

$$x_0=46\qquad N=103$$

$$\bar{x}=\frac{d}{N}\cdot\sum_{i=1}^{N}f_it_i+x_o=9,3$$

$$\overline{M_e}=L+d\cdot\frac{\frac{N}{2}-(f_1+f_2+.....+f_k)}{f_{k+1}}=/$$

There is not arithmetical medium, Medijana.

Table 7. The Cycle of emptying the container [6].

Interval of time of service	x_i	f_i	t_i	f_it_i	$f_it_i^2$	$f_it_i^3$	$f_it_i^4$
2-10	6	92	-5	-460	2300	-11500	57500
10-18	16	4	-4	-16	64	-256	1024
18-26	22	1	-3	-3	9	-27	81
26-34	30	0	-2	0	0	0	0
34-42	38	3	-1	-3	3	-3	3
42-50	46	1	0	0	0	0	0
50-58	54	0	1	0	0	0	0
58-66	62	0	2	0	0	0	0
66-74	70	0	3	0	0	0	0
74-82	78	0	4	0	0	0	0
82-90	86	2	5	10	50	250	1250
$\sum$		103		-472	2426	-11536	59858

There is not, because geometrically viewed the histogram could not be divided in two equal parts, and because of that if it should exist it should be found in the first interval, which mathematically viewed that is not possible (it should exist previous and following interval).

$$\overline{M_o} = L + d \cdot \frac{\Delta 1}{\Delta 1 + \Delta 2} = 6{,}1$$

$$s^2 = \frac{d^2}{N} \cdot \left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N} \cdot \left(\sum_{i=1}^{N} f_i t_i \right)^2 \right] = 163{,}45$$

$$s = 12{,}78$$

$$\overline{K_v} = \frac{s}{x} \cdot 100(\%) = 137{,}4\%$$

$$\overline{\mu_3} = \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 - 3 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 2 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^3 = 9903{,}2$$

$$\overline{\mu_4} = \frac{d^4}{N} \cdot \sum_{i=1}^{N} f_i t_i^4 - 4 \cdot \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 6 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^2 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 - 3 \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^4 = 708019{,}76$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu}_3}{s^3} = 4{,}7$$

V CYCLE: Taking down (Comprises taking down of empty container from the vehicle with which the communal waste is collected (from the vehicle to the ground).

The calculations about the taking down cycle, are the following

$$\text{min}=2; \quad \text{max}=69 \quad d = \frac{\text{min} - \text{max}}{N} = 6{,}1$$

$$x_0 = 35{,}55 \qquad N = 103$$

$$\bar{x} = \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i + x_o = 6{,}2$$

$$\overline{M}_e = L + d \cdot \frac{\frac{N}{2} - (f_1 + f_2 + \ldots\ldots + f_k)}{f_{k+1}} = /$$

There is not arithmetical medium, Medijana.

There is not, because geometrically viewed the histogram could not be divided in two equal parts, and because of that if it should exist it should be found in the first interval, which mathematically viewed that is not possible (it should exist previous and following interval).

$$\overline{M_o} = L + d \cdot \frac{\Delta 1}{\Delta 1 + \Delta 2} = 5{,}2$$

Table 8. The Cycle of taking down the container from the vehicle [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
2-8.1	5.05	92	-5	-460	2300	-11500	57500
8.1-14.2	11.15	10	-4	-40	160	-640	2560
14.2-20.3	17.25	0	-3	0	0	0	0
20.3-26.4	23.35	0	-2	0	0	0	0
26.4-32.5	29.45	0	-1	0	0	0	0
32.5-38.6	**35.55**	0	0	0	0	0	0
38.6-44.7	41.65	0	1	0	0	0	0
44.7-50.8	47.75	0	2	0	0	0	0
50.8-56.9	53.85	0	3	0	0	0	0
56.9-63	59.95	0	4	0	0	0	0
63-69	66.05	1	5	5	25	125	625
$\sum$		103		-495	2485	-12015	60685

$$s^2 = \frac{d^2}{N} \cdot \left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N} \cdot \left(\sum_{i=1}^{N} f_i t_i \right)^2 \right] = 38,34$$

$$s = 6,19$$

$$\overline{K_v} = \frac{s}{x} \cdot 100(\%) = 99,84\%$$

$$\overline{\mu_3} = \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 - 3 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 2 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^3 = 2125,9$$

$$\overline{\mu_4} = \frac{d^4}{N} \cdot \sum_{i=1}^{N} f_i t_i^4 - 4 \cdot \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 6 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^2 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 - 3 \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^4 = 123945$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu_3}}{s^3} = 8,96$$

VI CYCLE: Returning (Comprises returning of empty container from the vehicle with which the communal waste is collected to the stationary position of the container.

The calculations about the returning cycle, are the following

min=1; max=35 $d = \frac{\min - \max}{N} = 3,1$

$x_0 = 18,05$ $N=103$

$$\bar{x} = \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i + x_o = 5,0$$

$$\overline{M_e} = L + d \cdot \frac{\frac{N}{2} - (f_1 + f_2 + ... + f_k)}{f_{k+1}} = /$$

There is not arithmetical medium, Medijana.

There is not, because geometrically viewed the histogram could not be divided in two equal parts, and because of that if it should exist it should be found in the first interval, which mathematically viewed that is not possible (it should exist previous and following interval).

$$\overline{M_o} = L + d \cdot \frac{\Delta 1}{\Delta 1 + \Delta 2} = 2,9$$

$$s^2 = \frac{d^2}{N} \cdot \left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N} \cdot \left(\sum_{i=1}^{N} f_i t_i \right)^2 \right] = 24,57$$

$$s = 4,96$$

$$\overline{K_v} = \frac{s}{x} \cdot 100(\%) = 9\ ,2\%$$

$$\overline{\mu_3} = \frac{d^3}{N} \cdot \sum_{i=1}^{N} f_i t_i^3 - 3 \cdot \frac{d^2}{N} \cdot \sum_{i=1}^{N} f_i t_i^2 \cdot \frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i +$$

$$+ 2 \cdot \left(\frac{d}{N} \cdot \sum_{i=1}^{N} f_i t_i \right)^3 = 463,9$$

Table 9. The Cycle of returning the container from the vehicle to the place where it is positioned [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
1-4.1	2.55	63	-5	-315	1575	-7875	39375
4.1-7.2	5.65	23	-4	-92	368	-1472	5888
7.2-10.3	8.75	9	-3	-27	81	-243	729
10.3-13.4	11.85	4	-2	-8	16	-32	64
13.4-16.5	14.95	2	-1	-2	2	-2	2
16.5-19.6	**18.05**	0	0	0	0	0	0
19.6-22.7	21.15	0	1	0	0	0	0
22.7-25.8	24.25	0	2	0	0	0	0
25.8-28.9	27.35	0	3	0	0	0	0
28.9-32	30.45	0	4	0	0	0	0
32-35	33.55	2	5	10	50	250	1250
$\sum$		103		-434	2092	-9374	47308

$$\overline{\mu_4} = \frac{d^4}{N}\cdot\sum_{i=1}^{N} f_i t_i^4 - 4\cdot\frac{d^3}{N}\cdot\sum_{i=1}^{N} f_i t_i^3\cdot\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i +$$

$$+6\cdot\left(\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i\right)^2\cdot\frac{d^2}{N}\cdot\sum_{i=1}^{N} f_i t_i^2 - 3\left(\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i\right)^4 = 463{,}9$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu}_3}{s^3} = 3{,}8$$

Total time of service per container

The calculations about the total time of service per container, are the following

min=36; max=258 $d = \frac{\min - \max}{N} = 20{,}18$

$$x_0 = 146{,}99 \qquad N = 103$$

$$\overline{x} = \frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i + x_o = 72{,}7$$

$$\overline{M_e} = L + d\cdot\frac{\frac{N}{2} - (f_1 + f_2 + \ldots\ldots + f_k)}{f_{k+1}} = 63{,}2$$

$$\overline{M_o} = L + d\cdot\frac{\Delta 1}{\Delta 1 + \Delta 2} = 57{,}74$$

$$s^2 = \frac{d^2}{N}\cdot\left[\sum_{i=1}^{N} f_i t_i^2 - \frac{1}{N}\cdot\left(\sum_{i=1}^{N} f_i t_i\right)^2\right] = 1266{,}88$$

$$s = 35{,}59$$

$$\overline{K_v} = \frac{s}{x}\cdot 100(\%) = 49{,}52\,\%$$

$$\overline{\mu_3} = \frac{d^3}{N}\cdot\sum_{i=1}^{N} f_i t_i^3 - 3\cdot\frac{d^2}{N}\cdot\sum_{i=1}^{N} f_i t_i^2\cdot\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i +$$

$$+2\cdot\left(\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i\right)^3 = 107958{,}66$$

$$\overline{\mu_4} = \frac{d^4}{N}\cdot\sum_{i=1}^{N} f_i t_i^4 - 4\cdot\frac{d^3}{N}\cdot\sum_{i=1}^{N} f_i t_i^3\cdot\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i +$$

$$+6\cdot\left(\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i\right)^2\cdot\frac{d^2}{N}\cdot\sum_{i=1}^{N} f_i t_i^2 - 3\left(\frac{d}{N}\cdot\sum_{i=1}^{N} f_i t_i\right)^4 = 15224570{,}9$$

Coefficient of asymmetry:

$$K_A = \frac{\overline{\mu}_3}{s^3} = 2{,}31$$

From the data obtained during monitoring it is difficult immediately to perceive correctness of any kind. Therefore it was necessary to perform some subordination and to give to it adequate form. Part of the previously quoted was forming of statistical tables so as to make it easy the further analysis. The geometrical illustration of the statistical table is called histogram of the distribution of the frequencies, which in fact is a sequence of rectangles, whose side that lies on the x – axle is denoting the length of the interval and the height

Table 10. Total time of service per each container [6].

Interval of time of service	x_i	f_i	t_i	$f_i t_i$	$f_i t_i^2$	$f_i t_i^3$	$f_i t_i^4$
36-56.18	46.09	39	-5	-195	975	-4875	24375
56.18-76.36	66.27	36	-4	-144	576	-2304	9216
76.36-96.54	86.45	10	-3	-30	90	-270	810
96.54-116.72	106.63	9	-2	-18	36	-72	144
116.72-136.9	126.81	2	-1	-2	2	-2	2
136.9-157.08	146.99	3	0	0	0	0	0
157.08-177.26	167.17	2	1	2	2	2	2
177.26-197.44	187.35	0	2	0	0	0	0
197.44-217.62	207.53	1	3	3	9	27	81
217.62-237.8	227.71	0	4	0	0	0	0
237.8-258	247.89	1	5	5	25	125	625
$\sum$		103		-379	1715	-7369	35255

Table 11. Review of exponential distribution for the total time of service [6].

Interval	x_i	f_i	f_{it}	$f_i - f_t$	$\frac{[f_i - f_t]^2}{f_t}$
36-56.18	46.09	39	0.023	38.977	66 052.1
56.18-76.36	66.27	36	0.03	35.97	43 128.03
76.36-96.54	86.45	10	3.2	6.8	14.45
96.54-116.72	106.63	9	3.79	5.21	7.16
116.72-136.9	126.81	2	12.46	-10.46	8.78
136.9-157.08	146.99	3	10.5	-7.5	5.36
157.08-177.26	167.17	2	12.46	-10.46	8.78
177.26-197.44	187.35	0	17.51	-17.51	17.51
197.44-217.62	207.53	1	14.77	-13.77	12.8
217.62-237.8	227.71	0	17.51	-17.51	17.51
237.8-258	247.89	1	14.77	-13.77	12.8
$\sum$		103			109 285.28

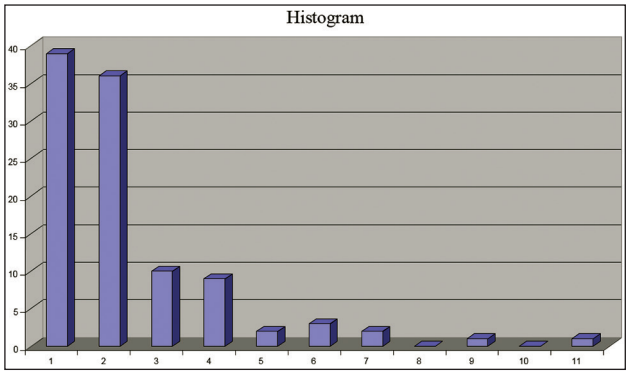
of the rectangles is adequate to the frequency of each of the intervals.

We have supposed that we could represent the statistical multitude with distribution that belongs to some of the families of the exponential theoretical distribution. We have supposed that it is exponential distribution with parameters:

$$f_x = \lambda \cdot e^{-\lambda x}$$

Where:

$$\overline{X} = \frac{1}{\lambda}, \qquad \lambda = \frac{1}{\overline{x}} = \frac{1}{72.7} = 0.013$$



Graphic 1. Histogram

Because of the exponential distribution of form $f(x) = \lambda \bullet e^{-\lambda x}$ was not characterizing the operating trait we have approached to monitoring of the empirical distribution of the frequencies of the sample. After that the following values were obtained, that are represented in the following table no. 12.

$f_r = \frac{f_i}{N}$ - Relative frequency

$f_k = \sum_{i=1}^{N} P(x_i)$ - Cumulative frequency

Table 12. Table for probability and cumulative probability [6].

Interval	x_i	f_i	f_{it}	f_k
36-56	46	39	0.379	0.379
56-76	66	36	0.350	0.729
76-96	86	10	0.097	0.826
96-116	106	9	0.087	0.913
116-136	126	2	0.019	0.932
136-156	146	3	0.029	0.961
156-176	166	2	0.019	0.980
176-196	186	0	0	0.980
196-216	206	1	0.010	0.990
216-236	226	0	0	0.990
236-256	246	1	0.010	1
$\sum$		103	1	

Since the frequencies were obtained and cumulative frequencies from the table of random numbers, quite random chosen numbers were determined, from which it appears the following table number 13 where it is represented the simulated time of service of all 103 cases.

Table 13. Simulated sample on the bases of cumulative frequencies [6].

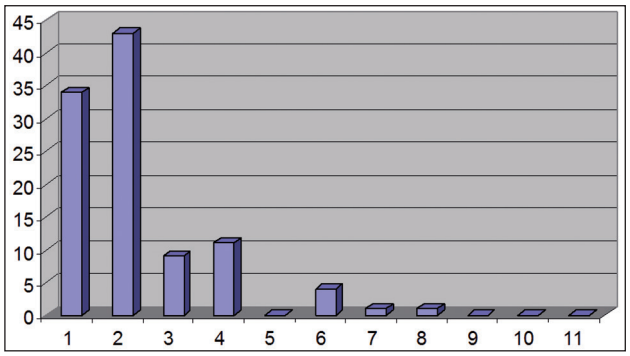
Number of Container	Random Number	f_s	Number of Container	Random Number	f_s	Number of Container	Random Number	f_s	Number of Container	Random Number	f_s
1	0.509	66	27	0.761	86	53	0.142	46	79	0.389	66
2	0.537	66	28	0.242	46	54	0.729	66	80	0.603	66
3	0.071	46	29	0.420	66	55	0.143	46	81	0.406	66
4	0.235	46	30	0.328	46	56	0.349	46	82	0.566	66
5	0.715	66	31	0.957	146	57	0.470	66	83	0.906	106
6	0.114	46	32	0.852	106	58	0.801	86	84	0.835	106
7	0.598	66	33	0.529	66	59	0.727	66	85	0.678	66
8	0.602	66	34	0.202	46	60	0.470	66	86	0.426	66
9	0.830	106	35	0.030	46	61	0.790	86	87	0.585	66
10	0.154	46	36	0.551	66	62	0.055	46	88	0.818	86
11	0.895	106	37	0.018	46	63	0.857	106	89	0.682	66
12	0.151	46	38	0.018	46	64	0.212	46	90	0.253	46
13	0.608	66	39	0.771	86	65	0.674	66	91	0.978	186
14	0.185	46	40	0.203	46	66	0.945	146	92	0.748	86
15	0.694	66	41	0.542	66	67	0.584	66	93	0.757	86
16	0.527	66	42	0.424	66	68	0.395	66	94	0.018	46
17	0.517	66	43	0.375	46	69	0.517	66	95	0.067	46
18	0.143	46	44	0.917	166	70	0.270	46	96	0.201	46
19	0.953	146	45	0.502	66	71	0.076	46	97	0.073	46
20	0.948	146	46	0.845	106	72	0.432	66	98	0.877	106
21	0.669	66	47	0.533	66	73	0.035	46	99	0.510	66
22	0.611	66	48	0.350	46	74	0.784	86	100	0.479	66
23	0.672	66	49	0.356	46	75	0.518	66	101	0.479	66
24	0.876	106	50	0.685	66	76	0.781	86	102	0.829	106
25	0.530	66	51	0.292	46	77	0.894	106	103	0.039	46
26	0.651	66	52	0.172	46	78	0.079	46			

The simulation was performed with selection of random numbers which were taken from the number 5095 to 9039 in rows and were divided with one thousand because the cumulative frequencies are decimal numbers.

Since the simulation was performed and values obtained, a simulation multitude was composed, and xi square test was calculated so as to check if the performed simulation meets the required expectations. These obtained results and the check of xi square test are represented in the table no. 14, and the histogram about the mentioned values is given after the tabular presentation.

Table 14. Simulation multitude and xi square test [6].

Interval	x_i	f_i	f_s	$f_i - f_s$	$\frac{(f_i - f_s)^2}{f_s}$
36-56	46	39	34	5	0,74
56-76	66	36	43	-7	1,14
76-96	86	10	9	1	0,11
96-116	106	9	11	-2	0,36
116-136	126	2	0	2	0
136-156	146	3	4	-1	0,25
156-176	166	2	1	1	1
176-196	186	0	1	-1	1
196-216	206	1	0	1	0
216-236	226	0	0	0	0
236-256	246	1	0	1	0
$\sum$		103	103		4,6



Graphic 2. Histogram

Because $Xs^2 < X_{0.05}^2$ there is no reason to reject the simulation.

Conclusion

After performed counting which were done at the field in the determined area, times of service per container were obtained and the same times were registered in the applications, and they obtained tabular form. The following step was to calculate the total time of service per each container individually, which actually represents a sum of the times of individual cycles for the given container. That time in the case of service per one container amounted 72.7 seconds.

These data with further processing and adequate analyses should give adequate solutions for following rationalization of the complete process of collection of the container communal waste at the area of the town of Bitola. And therefore the next step that followed the complete procedure was the simulation of time of service per containers.

After that when the processing of obtained data was performed, adequate mathematical-statistical calculation and analyses were performed, during which the values could not be comprised with certain theoretical distribution, so it approached to simulation performed in an empirical way i.e. for the relative frequencies and the cumulative frequencies. This simulation was ok and gave the desirable results.

Al that was stated in this paper was in a direction of qualitative and maintainable logistic solution in future, which in its essence will have the mathematical elements of consideration. Only in this way this research will be justified and will obtain its own logistical implementation in the reality.

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Influence of turning cutter types on the students' product quality

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Abstract

This study aims to investigate the suitable cutter type in lathe operation and and the geometric quality of lathe practice product. This study scrutinized the usage of various types of cutting angles and its effects on the products of the lathe operation. This was a quantitative descriptive study. The research population comprised students majoring Machine Engineering Education at Faculty of Engineering of Yogyakarta State University (YSU) who carried out machining practice. The research samples were 12 students undertaking Lathe Machining Practice subject. The data were obtained through observation and collection of the workpiece of the lathe machining practice product. The data then were analyzed by means of descriptive statistical techniques. The result of the study showed that the suitable turning cutter type used in lathe operation was the oblique one. The geometric quality on the surface texture aspect of the lathe machining practice product using the oblique turning cutter type was 3.16 μm or equivalent to N8 according to the ISO standards, and was 5.08 μm when using the orthogonal turning cutter type. The processing time needed when using the oblique turning cutter type was 27 minutes, while when using the orthogonal turning cutter type was 36.66 minutes.

Key words: lathe machining, turning cutter type, product quality

1. Introduction

The teaching and learning process in Machine Engineering Education Department of Faculty of Engineering YSU consists of theoretical and practical learning. Theoretical learning is about engineering and general theories, and the learning process is carried out in classroom by employing various teaching methods and media. Practical learning includes materials to educate students about a set of skills which is then referred to as competence, and the learning process is conducted in a workshop equipped with adequate facilities and materials.

Practical learning demands a multitude of different requirements when compared to theoretical learning. A very salient difference exists in the learning facilities and infrastructure. Furthermore, practical learning necessitates a workshop completed with practice facilities such as machine, cutting tool, attachment of machining practice, measuring tool, practice materials, and a set of job sheets.

Specifically, practical learning in lathe machining requires machine tools as well as the aiding tools, various types of cutting tools, measuring equipment, practice materials, and job sheets. In this learning process, students are guided, accompanied, and supervised by a lecturer or a practice instructor, so that the products meet the standard requirements.

The quality of lathe machining product is determined by the student's ability in executing the machining process; it means that the student must be smart in selecting the turning cutter and determining the machining process parameter, steps of work, and other parameters related to the lathe machining process. One thing that really matters in determining the product quality is the student's capability in utilizing cutting tools including how he/she chooses the turning cutter type suitable for the undertaken material and the turning cutter type used in the machining process, and how he/she grinds the turning cutter when damaged.

Facts from the field showed that not only were the students unable to choose what type of turning cutter to use is, but also they were not able to sharpen their cutter as instructed by the rules yet. Another fact revealed that the quality of the products the students made did not meet the required standard; for instance in the precision of the measuring dimension, tolerance, and surface texture. Thus, these results would affect the students' achievement in lathe machining.

Some problems occurred in lathe machining practical learning processes were as follows: the students were not used to determining the lathe machining process parameter; the students were not accustomed to examining the work steps in lathe machining process; the students were unfamiliar with the turning cutter type that would be used in lathe machining process; the types of turning cutter that would be used were limited; and the turning cutter sharpening tools were not completely available to suit the turning cutter type used by the students.

In accordance with those field based facts, problems related to turning cutter type and its effects on the product quality of the lathe machining practice would be investigated. The research problems in this study were limited to those of turning cutter type. In this study, the types of turning cutter and their effects on the product quality of the lathe machining practice were examined. The executed job sheet was the straight turning lathe; the material used was mild steel; and the type of the turning cutter employed was high speed steel or HSS. The oblique cutter angle was determined between 130° and 145°; while the orthogonal one was 90°.

The investigated problems focused on the types of turning cutter and the geometric quality of lathe machining practice product of students majoring Machine Engineering Education, Faculty of Engineering, Yogyakarta State University (YSU).

2. Literature review

2.1 The Definition of Lathe Machine

Lathe is a machine tool of which working process includes rotating and cutting a workpiece by using a single-point cutting tool in the form of a cutter. Lathe is one of production processing machines which is usually used to shape a cylindrical workpiece. The engine rotation is derived from an electric motor connected to the workpiece through a series of gears arranged in such a way that the rotation speed can be adjusted. The main function of conventional lathes is to make cylindrical-type objects, for instance straight axle, step shaft, cone shaft, groove shaft, screw thread, and various other shapes with cylindrical surface.

The types of lathe operation (other than the straight turning lathe operation) are as follows [1]:

a. Facing: creating flat surfaces on a workpiece, or fitting the length of a workpiece.
b. Taper Turning: making an angle toward the axis in order to create a conical shape.
c. Contour Turning: shaping a workpiece by following a contour, thus creating an object with the same contour as shaped.
d. Form Turning: using a cutter of a certain shape to be imparted by plunging it radially into the workpiece.
e. Chamfering: an operation on the extreme end of a cylinder with a certain cutting angle as determined in the instruction.
f. Cutoff: cutting by feeding a rotating workpiece radially to a certain part of the machine.
g. Threading: creating screw thread and axis by linearly feeding a pointed cutter to cut the external surface of a rotating workpiece in a certain feeding speed.
h. Boring: enlarging the diameter of a workpiece or softening its surface by a means of a single-point cutting tool fed linearly to the axis to the hole that has already been made earlier. This process is usually referred to as internal lathe.
i. Drilling: drilling can be done on a lathe machine by feeding a twist drill to a rotating workpiece on its axis. Reaming can also be made in this way.
j. Knurling: a metal shaping operation to create a crisscross pattern on its external surface. Knurling is shaped by means of a knurling tool in the form of a hard shaped roller. The surface of a rotating workpiece is pressed to the roller so that a knurling pattern is formed.

2.2 Turning Cutter

Turning cutter is used to cut a workpiece starting from the roughing to the finishing process. The types of turning cutter are varied depending on the type and the lathe operation requirements. This cutter is made of a hard material. There are two types of turning cutter: a cutter made of HSS (High Speed Steel) and a cutter made of carbide [2], [3]. The latter is a tipped cutter installed in its holder. Carbide is so fragile that it will be easily broken when hit sudden-

ly. To work on soft materials with mild hardness, we can use a HSS cutter. Not only is the price cheaper, but HSS cutter is also more efficient and economical compared to the carbide one. Meanwhile, to work on materials with high hardness level, carbide cutter is more suitable and efficient to use. There are two kinds of cutters used in the cutting process of lathe machining, which are roughing cutter and finishing cutter. During the roughing process, a cutter must cut a workpiece within a short time. Thus, a roughing cutter which is strong in its construction is used. In order to make a softer surface, it is best to use a finishing cutter. There are two types of finishing cutters, namely "single point finishing cutter" and "flat finishing cutter" [4]. The former has a round cut side, while the latter has a flat cutting edge.

Those two cutter types have various shapes depending on the sorts of the undertaken jobs. In general, the lathe cutter shape can be seen in Figure 1. However, in its development, cutting angles can be designed or modified in accordance with the kinds of the lathe operation to be done.

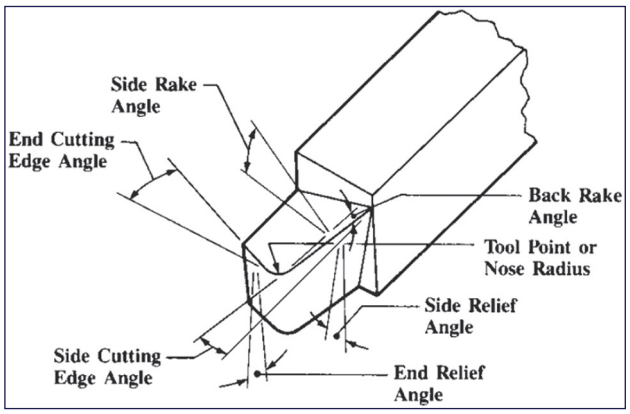

Figure 1. Turning cutter with its cutting angle dimensions

Lathe cutter types used to flat a surface are categorized into two: orthogonal and oblique [1]. This categorization is based on the lathe machining production process. Each type has its own strengths and weaknesses. Orthogonal cutter has a 90° cutting angle making it possible to reach the right angle of a levelled cutting, see Figure 2; however it requires a great effort to operate and does not last long. On the other hand, oblique cutter can create a wider cutting angle by little effort; yet it is not suitable for lathe operation in a levelled cutting, see Figure 3.

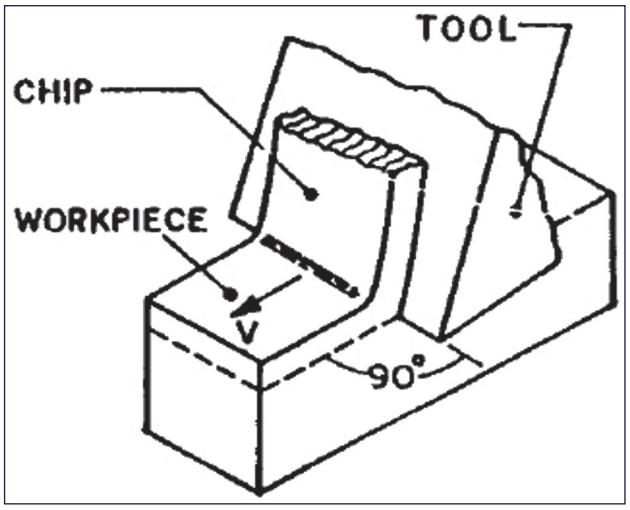

Figure 2. Orthogonal cutter

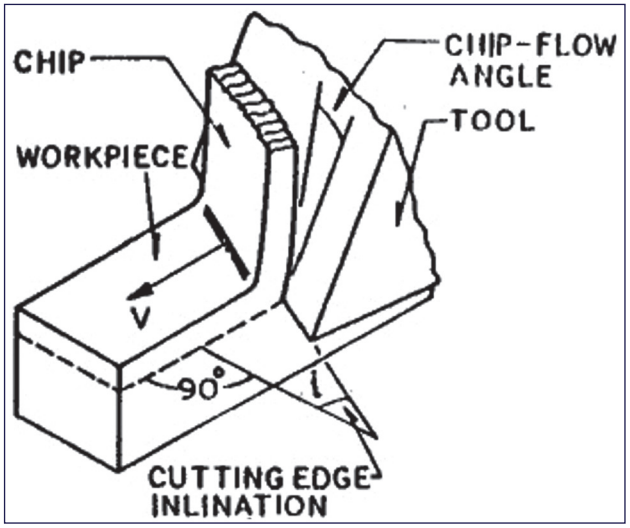

Figure 3. Oblique cutter

2.3 The Definition of Geometric Quality

Quality control over a product in machining is a process of controlling the product quality and ensuring that the product has met the required specifications. For example, production quality is when a turner is about to make a machine such as an axis, he will make it in a certain size as modelled on the design and list its geometric characteristics. By doing so, this product will have a certain quality which is called production quality. This kind of quality in a machinery product term has an ideal geometric characteristic if the product suits the design in the following aspects [5]:

a. Precision
b. Excellent form
c. Surface finish

One of some relevant research used as a consideration in conducting this study was a study about durability analysis of a high speed steel turning cutter which was implanted with nitrogen ions. The results of the study showed that maximum hardness was reached when the energy was 100 toward Y and the ion dose was 2,516 x 1016 ion/cm2, i.e. 1219 VHN 0,01, and the initial hardness was 595 VHN 0,01. The turning cutter implanted with nitrogen ions in this amount of energy and dose and at a cutting speed of 25 meter/minute increased the cutter durability as much as 83% [6].

Another study concerning the effects of turning cutter type on the texture of lathe operation product revealed that based on the Ra parameter, the surface texture produced by boron carbide cutter type was 1,16 μm, provided that the lathe operation parameters were: machine spin (N) = 1500 rpm, cutting speed (Vc) = 89 meter/minute, and depth of cut (DOC) = 0.25 mm [7].

This study was based on a thought that the quality of lathe operation product was determined by the usage of cutter type which matches the lathe operation parameter. The appropriate cutter usage would make the machining process quicker and create an ideal geometric quality. Grounded on those thoughts, the research problems of this study are as follows:

a. What cutter type is appropriate to be used in the lathe machining process of Machine Engineering Education Department students of Faculty of Engineering YSU?
b. How is the geometric quality of the lathe machining practice product of Machine Engineering Education Department students of Faculty of Engineering YSU?

3. Research method

This research was aimed at investigating the usage of turning cutter in its various cutting angle types. The main aspect to consider in this study was to prove whether a turning cutter with different cutting angle will create different result in the lathe operation or not. This was a quantitative descriptive study. This method was chosen as the data observed in this study were very limited resulting in the unfulfilled statistical analysis criteria.

The procedures in conducting this research were as follows:

1. Dividing the research groups into two: orthogonal cutter group and oblique cutter group.
2. Preparing turning cutter types to be used: orthogonal and oblique cutter.
3. Undertaking the research in both groups.
4. Checking the lathe machining products of the students based on their groups' cutter type.
5. Giving recommendation on the results of their lathe machining.

The research population comprised students majoring Machine Engineering Education at Faculty of Engineering of YSU who carried out machining practice. The samples were students of A class undertaking Lathe Machining Practice subject with a total of 12 students.

The data were obtained through observation and collection of the workpiece of the lathe machining practice products. The research instruments were micrometers of 0 – 25 mm and 25 – 50 mm with accuracy of 0.01 mm, surface texture comparator for lathe machining, calipers of 0 - 180 mm with accuracy of 0.02 mm, lathe machine with a capacity of Ø 300 mm, length 1000 mm, and power 3 HP.

Those instruments were validated by calibrating them using B-accuracy measurement block and optical flat, lathe machine accuracy with an average deviation of 0.03 mm. The lathe cutter setting on the tool post was equal to twice the cutting edge. The surface texture was measured using surface texture comparator of which the results were confirmed to the ISO standards.

The data analysis technique implemented in this study was descriptive statistics, i.e. comparing the products of the two groups: orthogonal and oblique cutter type group.

4. Research results and discussions

This research on the influence of cutter types on the product quality of lathe machining practice was conducted in a workshop of Machine Engineering Education Department, Faculty of Engineering, YSU, by using a practice facility, namely lathe machine. The research results concerned the usage of cutter types, orthogonal and oblique cut-

Table 1. Research results on the usage of orthogonal and oblique cutter

Subject	Workpiece Ø (mm)	Machine Spin (rpm)	Feeding (mm)	Feeding Depth (mm)	Time (minute)	Texture (µm)
Oblique Cutter						
1	40	450	0.5	1.5	25	3
2	40	450	0.5	1.5	30	2.5
3	40	450	0.5	1.5	27	3
4	40	450	0.5	1.5	25	3.5
5	40	450	0.5	1.5	25	3
6	40	450	0.5	1.5	30	4
	Mean				27	3.16
Orthogonal Cutter						
1	40	450	0.5	1.5	37	4
2	40	450	0.5	1.5	34	4.5
3	40	450	0.5	1.5	36	5
4	40	450	0.5	1.5	30	5
5	40	450	0.5	1.5	40	6.5
6	40	450	0.5	1.5	43	5.5
	Mean				**36.66**	**5.08**

ter, by controlling the machine spin, cutting speed, feeding, and feeding depth. The results of this study can be seen in Table 1.

Table 1 shows that when using oblique cutter, the average processing time reached by the students is 27 minutes and the average geometric quality on the performance aspect has a surface texture of 3.16 µm. This is equal to N8 on the ISO standards. While when using orthogonal cutter, the students' average processing time is 36.66 minutes and the geometric quality on the performance aspect is 5.08 µm which is equal to N9 on the ISO standards.

The results show that it is practically proven that the oblique cutter has more advantages than the other cutter type, i.e. it can cut deeper without having any damage on its cutting edge. The cutting angle position is just like when a knife cuts thing so that the object has no rough texture. With this capability, the processing time will be shorter

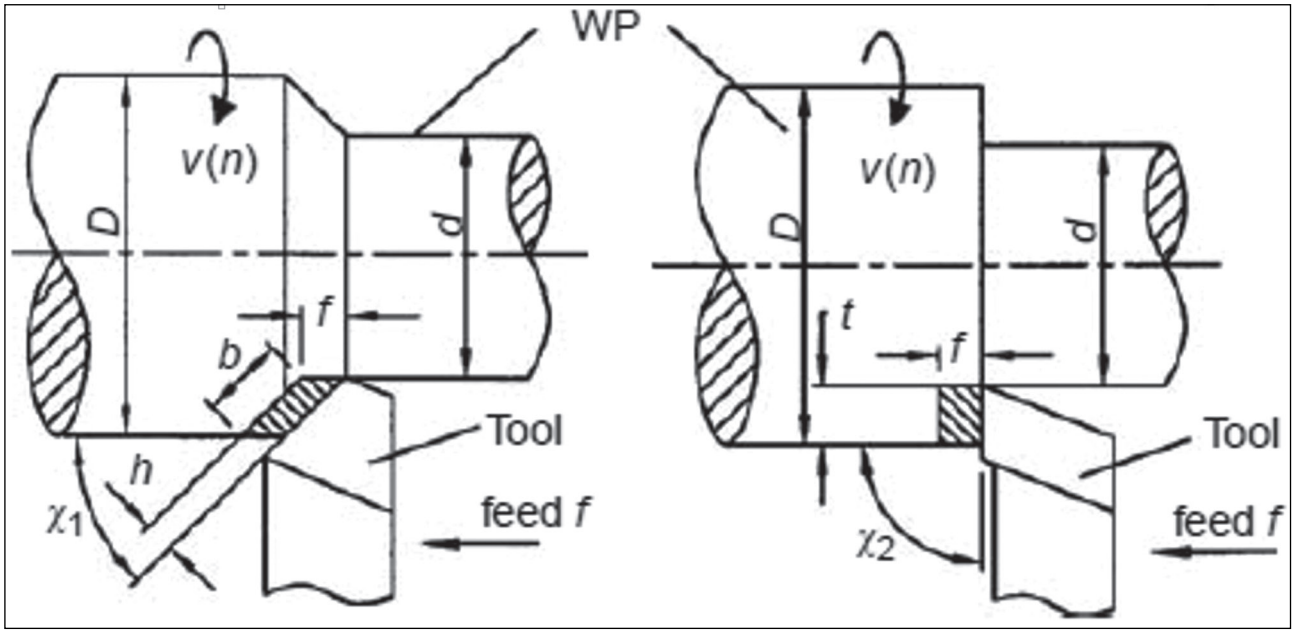

Figure 4. Cutting position: (a) oblique cutter, (b) orthogonal cutter (Helmi A. Youssef., Hassan. El. Hofy, 2008: 60).

and the cutting result is better as the cutter is not damaged during the process; thus it does not take time. If attached to the workpiece or set perpendicularly to the workpiece axis, the cutting angle of this cutter will be less than 90° (look at Figure 4a). When used with this cutting angle position, the cutting edge can produce a large cutting volume [1]. In addition, with an angle of less than 90°, the force used by the lathe machine is small; it is so because the cutting is not frontal, either from the workpiece radial or axial direction. When viewed from the force occurring on the workpiece with a less than 90° of cutting angle position toward the workpiece surface, theoretically the force is then relatively small.

In orthogonal cutter case, it is theoretically proven that unlike an oblique cutter, orthogonal cutter cannot cut thick material; thus, if forced the cutting edge angle will be badly damaged. It so happens because the cutting angle position is perpendicular or 90° to the workpiece surface (look at Figure 4b). In this position, the cutter will get a big force both from radial and axial direction resulting in a hampered cutter speed. If the cutter speed is hampered, the volume of the cutting result will be small; as a consequence, the machining time will be longer. It happens for when used with a great force, a cutter will be easily damaged, and the cutting process will be disturbed as there are always cutter reparations which take a considerable time. With this cutting angle condition, the geometric quality in its texture aspect will also be affected. The research results reveal that orthogonal cutter produces greater texture than oblique cutter does, i.e. 5.08 μm. Theoretically, orthogonal cutter requires greater machine power compared to the oblique one. This is because an orthogonal cutter is exposed to forces both from radial and axial direction.

Practically, the results of this study can be used to improve the learning of machining practice, specifically for the lathe machining process. By implementing these findings, the geometric quality and machining time can be better and more efficient; lathe machining practice job sheet can be completed on time; the cutter usage is not wasteful; and the machine power usage is low. Theoretically, these findings can be used to refine scientific materials on the theories of lathe machining process.

5. Conclusions and recommendations

5.1 Conclusions

The cutter type appropriate for lathe machining process is the oblique one. Its strengths include shorter processing time compared to that of the orthogonal type.

The geometric quality of lathe machining practice products of the students of Machine Engineering Education Department, Faculty of Engineering, YSU shows that by employing oblique cutter, the geometric quality of texture aspect can be well achieved at 3.16 μm or equal to N8 on the ISO standards. In addition, the processing time is shorter compared to that of the orthogonal one, i.e. 27 minutes.

5.2 Recommendation

In order that lathe machining practice can run well and the job sheets can be completed on time, it is suggested that lathe machining lecturer give referral to the students to use the oblique cutter type.

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Qualitative chemical and antibacterial analysis of ajurvedic preparations against alopecia

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Abstract

Hair loss is a widespread problem. The biochemical changes underlying this phenomenon are still very poorly understood. Today, the conventional medicine used is not very effective, but also carries various possible side effects. Such medicines include, minoxidil, finasteride and corticosteroids, depending on the type of alopecia. Therefore, more chemical agents with less undesirable effects and possibly better or stronger effects are being investigated, mainly from natural sources. Moreover, plants have been widely used to promote hair growth since ancient times, as recorded in Ayurveda, Chinese and Unani Medical Systems. Alternative medicine that is the most promising in this segment is the traditional Indian Ayurveda system. Some of the most appreciated plants in Ayurvedic medicine (applied in topical polyherbal formulations) include: *Azadirachta indica*, *Centella asiatica*, *Eclipta alba*, *Cyperus rotundus*, *Nardostachys jatamansi*, *Bacopa monnieri* and *Emblica officinalis*. Ayurvedic texts also describe the use of these plants in a number of other diseases, but in different preparations and mixtures. Today, there are many varied pharmacological effects which are confirmed in a number of studies. For this reason, this paper aims to present a review of the chemistry of the most important plants used in Ayurvedic preparations against alopecia, and investigate several mechanisms of action and their antibacterial properties.

Key words: hair loss, alopecia, Ayurveda, Azadirachta indica, Centella asiatica, Eclipta alba, Cyperus rotundus, Nardostachys jatamansi, Bacopa monnieri, Emblica officinalis

1. Introduction

The biology of hair

The hair follicle is one of the most complex "mini-organs" of the human body [1]. Nevertheless, many of the fundamental processes within it are not yet properly scientifically explained. However, it is well-known that this "mini organ", in addition to its main roles - the creation of hair, also has other roles: excretion, protection, regulation of the conservation of body heat, as an instrument of psychosocial communication and as a sensory organ. Most of these functions are performed by keratin fibers that form the visible part of the hair. To achieve these functions, hair follicles constantly pass through the following phases: fast growth (anagen), regression (catagen), telogen and decay (exogenous).

The follicle itself is composed of two cell layers inside the dermis- a dermal layer made up of fibrous tissue and an epithelial layer. At its proximal end it is expanded in the form of a port, called bulb. It has a dermal papilla on its inner side which is hollow at the base, which allows the flow of blood with nutrients, oxygen, and growth factors. The bulb contains trichocytes with granules of melatonin, keratinocytes and stem cells.

During the anagen phase, the hair within the follicle forms with all its associated components. In addition, during this phase the enzyme telomerase is active. This process resembles folliculogenesis which occurs prenatally and stops shortly before birth. This basically means that no new hair follicles form during postnatal development.

It is known that various factors, such as TGF-β (transforming growth factor), bone morphogenetic protein (BMP), Wnt signaling glycoproteins, Shh (Sonic-hedgehog) proteins, and neutrophils, are regulated in the induction process but also the

duration of the anagen phase [1]. The process of anagen ends with follicle involution resulting in apoptosis and terminal differentiation, after which the regression stage (catagen) occurs [1]. The most important feature of this phase, in morphological terms, is the condensation of the dermal papilla and the release of follicle bulb. The follicle is then condensed and the cell division is terminated. It is considered that the major gene responsible for crossing from the anagen into the catagen phase is the HR gene (bald gene or hairless gene). The gene acts as a negative transcriptional repressor.

During telogen, cells within the follicle remain dormant while the hair itself remains in its channel for a certain time, after which it falls out. The decline process itself is often referred to as a separate phase - phase 4 or the exogen.

Basic characteristics of alopecia

Alopecia is the medical term for hair loss. There are four different types of alopecia [2]. *Alopecia areata* represents hair loss in one place, usually on the head, in circular shapes resembling a seal. In most cases there is a complete hair loss in a rounded area which are referred to as alopetic axes (0.5mm-1cm in diameter) in the core area (60% of cases), which then spread and form irregularly formed alopetic areas. The area of is completely hairless, smooth, and without a visible change of skin color. The hairs around the area tend to fall out slowly, and the area is gradually enlarged.

Figure 1. Alopecia areata [2]

Alopecia totalis is the advanced form of alopecia areata where there is a total loss of hair from the scalp or the whole head (including eyebrows, eyelashes and chin). In a number of cases the occurrence of the disease may occur without previous alopecia areata- which is a sudden loss of entire body hair without previous minor alopetic areas.

Alopecia universalis is a state of complete hair loss on the whole body (both the scalp and the rest of the body). It can be considered a tertiary form of alopecia areata (if it has developed gradually from alopecia areata, through the totalis phase and ultimately to universal alopecia), or as a separate disease, if it is an abrupt manifestation or when a newborn does not appear to have normal and common hair growth.

Androgenic alopecia is a condition that, in spite of the name, affects both men and women. It is related to changes in the sensitivity of androgen receptors in hair follicles, which is genetically conditioned - increases susceptibility of hair follicles to circulating dihydrotestosterone; hence the name of androgenic alopecia. Men are more likely to be affected than women. While it can occur in men any time after puberty, women usually develop it after menopause.

Telogen Effluvium is one of the most common forms of alopecia, but at the same time the least investigated. It occurs mostly after a strong emotional, physical or hormonal stress (which is considered to be its most common causes), and involves all age groups. Some hormones that are considered to play a role in its aetiology are Supstance P, Prolactin, Cortisone, and ACTH. Antidepressants are also considered to trigger this type of alopecia.

Other forms of alopecia include cicatricial alopecia, *Alopecia Barbae*, tracheal alopecia, and *Anagen effluvium*.

The aetiology of alopecia is currently not known. Factors considered to be involved are emotional stress, the presence of a disease focus (focal points in the body - dental focuses, and chronic sinusitis and tonsillitis) and alopecia areata as an autoimmune disease. At present, a large number of experts in the field of alopecia research consider it to be an autoimmune diseases conditioned by genetic predisposition. The treatment of alopecia areata includes conventional anti-inflammatory medications is. First of all, taking the most likely autoimmune character of the condition as a standpoint, different corticosteroids are common-

ly used. In addition to (or with them) minoxidil is used as a vasodilator. But, the outcome of treatment is often uncertain.

2. Results and discussion

Alternative Indian medicine – Ayurveda and its approach to alopecia treatment

Ayurveda is the traditional medical system of India and is believed to be at least 6000 years old. It describes ways of preventing and treating diseases. Ayurvedic texts describe hair loss diseases in the Sanskrit term in Charak Samhita (Hindu Ancient Text in Sanskrit) as **Khalita** (Alopecia): means hair loss; **Palitya** (Premature graying of hair); **Indralup**: indicates alopecia areata, total alopecia, and universal alopecia.

Some plants and their mixtures are mentioned in the early texts of Charak Samhita, Sharangdhar Samhita Grantha, and are traditionally used in the treatment of alopecia since the time of Charak, an ancient leading physician and writer of the Ayrshire texts, born 300 years BC. There are still many different herbs and plants from that period which are mentioned in the modern Ayurvedic Pharmacopoeia of India.

Hair growth formulations are prepared by infusing drugs of these plants into a basis oil, and the prepared formulation (a fatty oil with multiple plant extracts in it) is applied topically, usually every second night, by rubbing or a light massage, and then washed out in the morning. Every carrier oil used to prepare these formulations are of natural origin. The most commonly used oil is sesame oil.

Sesame oil as a carrier for multiherbal formulations- Chemical composition

Sesame oil (*Sesamum indicum* L.) is the most commonly used carrier oil in Ayurvedic medicine. In addition, most polyherbal formulations use this oil as a base or carrier because it extracts various herbal chemicals used for hair growth. Proteins found in sesame oil are rich in methionine, an amino acid that contributes to hair growth and development. It nourishes the scalp in terms of preventing drying out, but it also prevents formation of dandruff, and it plays an important role in preventing skin infections. Sesame oil consists

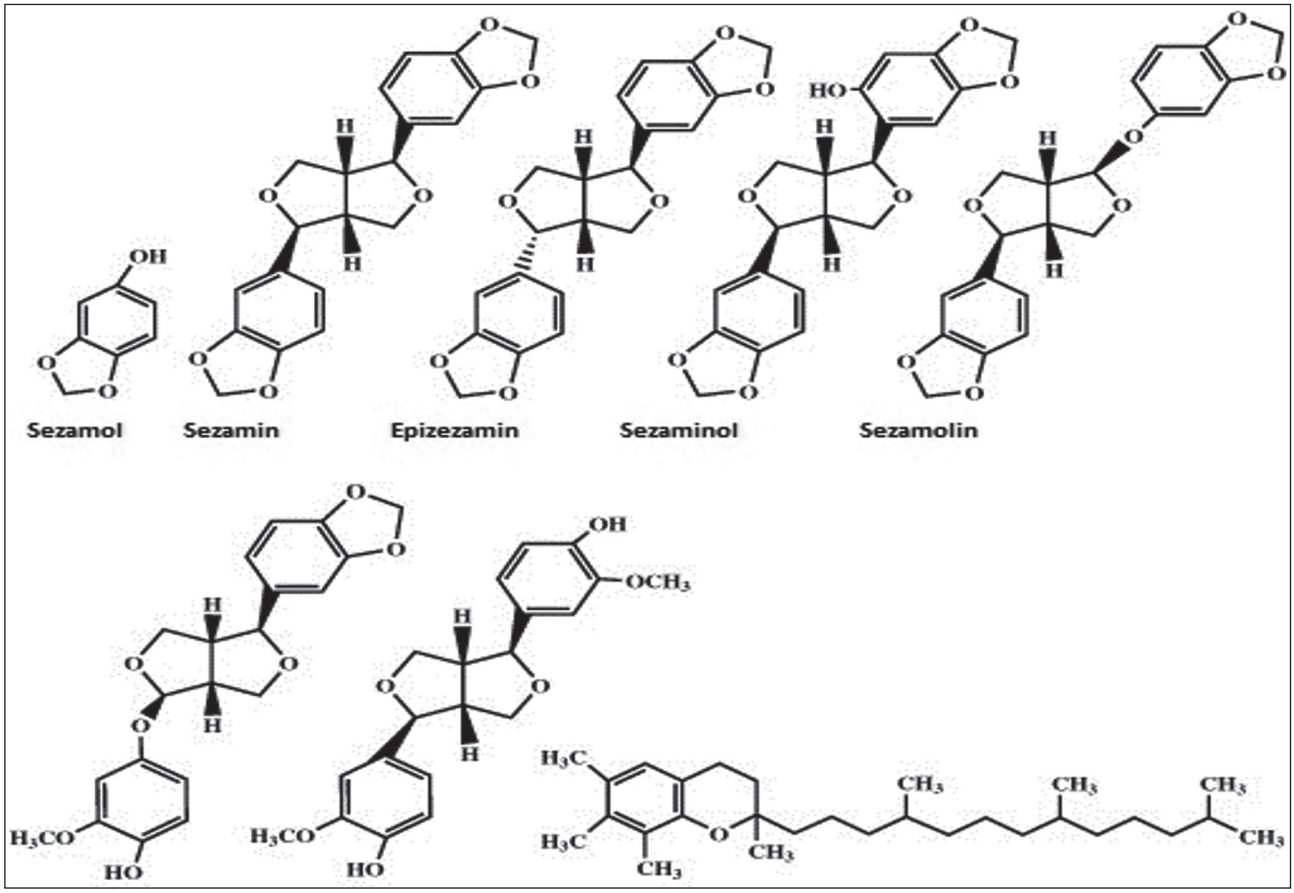

Figure 2. Structures of the most abundant tocopherols and lignans found in sesame oil [3]

primarily of unsaturated fatty acids, and to a lesser degree of saturated acids, and a significant amount of sterols, lignans and tocopherols.

A study from 2016 investigated the qualitative composition of phytosterols in *pro analisi* sesame oil and found that campesterol, stigmasterol and beta-sitosterol are the most abundant sterols found in the oil.

In addition to the main three phytosterols in sesame oil, 7-stigmasterol, 5-avenasterol and 7-avenasterol are also present. The phytosterols in sesame oil account for up to 1.9% of the total composition, making it one of the phytosterol richest oils found in nature. Sesame oil is one of the most stable oils one of the reasons being its high content of tocopherols (vitamin E). Sesame oil contains between 330 and 1010mg / kg of total tocopherol, mostly Y-tocopherol, 5% and δ-tocopherol, while α-tocopherol is only found in traces. However, in addition to the high content of tocopherols, the main substances that give sesame oil it stability are lignans.

The main lignans are sesamin and sesamolin. Sesamin is not specific to *Sesamum indicum* L. but can be found in other plants, while sesamolin is specific for sesame. Despite their abundance, the main pharmacologically active antioxidative substance is sesamol, which is derived from sesamolin through heating. Other notable lignans with similar effects include, sesaminol, sesamolinol, pinoresinol, matairesinol, and episelamine.

Plants used in most polyherbal ayurvedic hair growth formulations

Neem (*Azadirachta indica* A.Juss.)

Azadirachta indica is an evergreen tree of the genus *Azadirachta*, from the Meliaceae family, and naturally grows in the areas of southern Asia

Table 1. Chemical composition of Neem and their pharmacological characteristics [4]

Ser. no.	Supstance Name	Plant Part	Pharmacology
1.	Nimbidin	Fruit oil	Anti-inflammatory
			Anti-arthritic
			Diuretic
			Anti-fungal
			Spermicidal
			Antigastric
			Antibacterial
			Antipyretic
2.	Sodium mibidat		Anti-inflammatory
3.	Azadirahtin	Fruit oil	Antimalaric
4.	Nimbin	Fruit oil	Spermicidal
5.	Nimbolid	Fruit oil	Antimalaric
			Antibacterial
6.	Gedunin	Fruit oil	Antimalaric
			Antifungal
7.	Mahmudin	Fruit oil	Antibacterial
8.	Galic acid, epicatehin & catehin	Bark	Anti-inflammatory
			Immunomodulatory
9.	Margolon, mergolonon & isomergolonon	Bark	Antibacterial
10.	Cyclic trisulfid& cyclic tetrasulfid	Leaves	Antifungal
11.	Polysacharids	Bark	Anti-inflammatory
12.	Polysacharids G1A and G1B	Bark	Cytostatic
13.	Polysacharids G2A and G3A	Bark	Anti-inflammatory
14.	NB-2 peptidoglucan	Bark	Immunomodulatory
15.	Salanin		
16.	Meliantriol		

(primarily India, but also Pakistan, Sri Lanka, Nepal and Bangladesh). Neem is an evergreen tree usually growing between 15 and 20 meters, but can reach up to 40 meters in height. The branches are wide and the leaves are elongated - reaching between 20 and 40 centimeters are a dark green color. The flowers are scented and white and grouped in an axillary tube, 25 centimeters in length. The fruit is 1.4 - 2.8 cm in length and 1-1.5 cm wide, with a slick, light yellow color. The drug is composed of dried leaves and dried fruit.

Neem is traditionally used primarily as an alopecia treatment, but also for liver and blood detoxification, lowering blood glucose, and for various dermatological diseases. In addition, it also presents antifungal, antiviral, antibacterial, antidiabetic, contraceptive and sedative effects.

Antimicrobial properties

Numerous studies on the antimicrobial effects of A. Indica have shown efficient effects against several types of bacteria, viruses, fungi and parasites. It has been found in several repeated studies that the *A. indica* extract demonstrates considerable antimalarial activity by inhibiting the growth and development of both asexual and sexual phases of the parasitic development of Plasmodium falciparum. This antimalarial effect was also observed in sensory and chlorine - resistant strains [5]. Antimycotic activity was also observed in the genera *Trichophyton*, *Epidermophyton*, *Microsporum*, *Trichosporon*, *Geotricum* and *Candida* [6]

Antibacterial properties were observed in *Vibrio cholerae*, *Klebsiella pneumoniae*, *M. tuberculosis*, *M. pyogenes*, *Streptococcus mutans* and *S. faecalis*. The tetranotriterpen nimbolid, isolated from herbal oil, exhibits antibacterial activity against *S. aureus* and *S. coagulase*, while the triterpenoid azadirahtin has a mostly antimalarial activity [6].

Identification of the substances implicated in hair regenerative properties have not yet been confirmed and very little research has been conducted to prove this effect despite the long traditional use of this plant in Indian medicine against alopecia. Nevertheless, a study conducted by Rakesh et al. (2016) evaluated the effects of a multiherbal formulation (*Azadirachta indica*, *Semecarpus anacardium* and *Trigonella foenum graecum*) in coconut oil on hair growth in albino rats for 30 days. Skin biopsy of euthanized rats yielded positive results. The authors observed more hair follicles in the anagen phase and less telogen in comparison to control group [7].

Gotu Kola (*Centella asiatica* (L.) Urb.)

C. asiatica is a herbaceous perennial herb from the Apiaceae family. It grows naturally in wetland areas of tropical and subtropical Asia. The leaves are flat and without hair with a characteristic appearance. The flowers are white, pink, or white-reddish, miniature (not larger than 3mm), usually facing the ground and carry small oval fruit. The rhizome is horizontally located and covered with small hairs.

Gotu has been used in traditional Chinese and Indian medicine for millennia and it has numerous effects attributed to it. Substances for which pharmacological activity has been confirmed and isolated from *C. asiatica* are triterpenoids. Beside its use for alopecia treatment, Gotu is used as a sedative, a remedy for longevity, and for various dermatological diseases like psoriasis and eczema.

While researching the healing process in mice, it was confirmed that the formulations of gel and fat that contained Gotu extract healed faster than an untreated control group. It has been noted that apart from an increased collagen production, the Gotu extract also stimulates angiogenesis, cell proliferation, antioxidant activity and anti-inflammatory activity.

The main active compound found in Gotu is the triterpenoid asiaticoside. Asiaticoside is an effective activator of the enzyme collagen synthase and helps to promote the production of connective tissue. In addition, it has a supportive role in the treatment of venous insufficiency by stimulating the production of hyaluronidase and chondroitin sulfate. An increase in GABA in rat brain tissue was also observed after treatment with *C. asiatica* extract, leading to significant antiepileptic effects.

Chemical composition

C. asiatica has a diverse phytochemical profile and the most notable substances present in the plant include, among others, Triterpenoid acids (asiatic, madecasic, terminolic, centic, centelic, centenoic, indocentic, isobrahmic, brahmic, and betulaic acid);

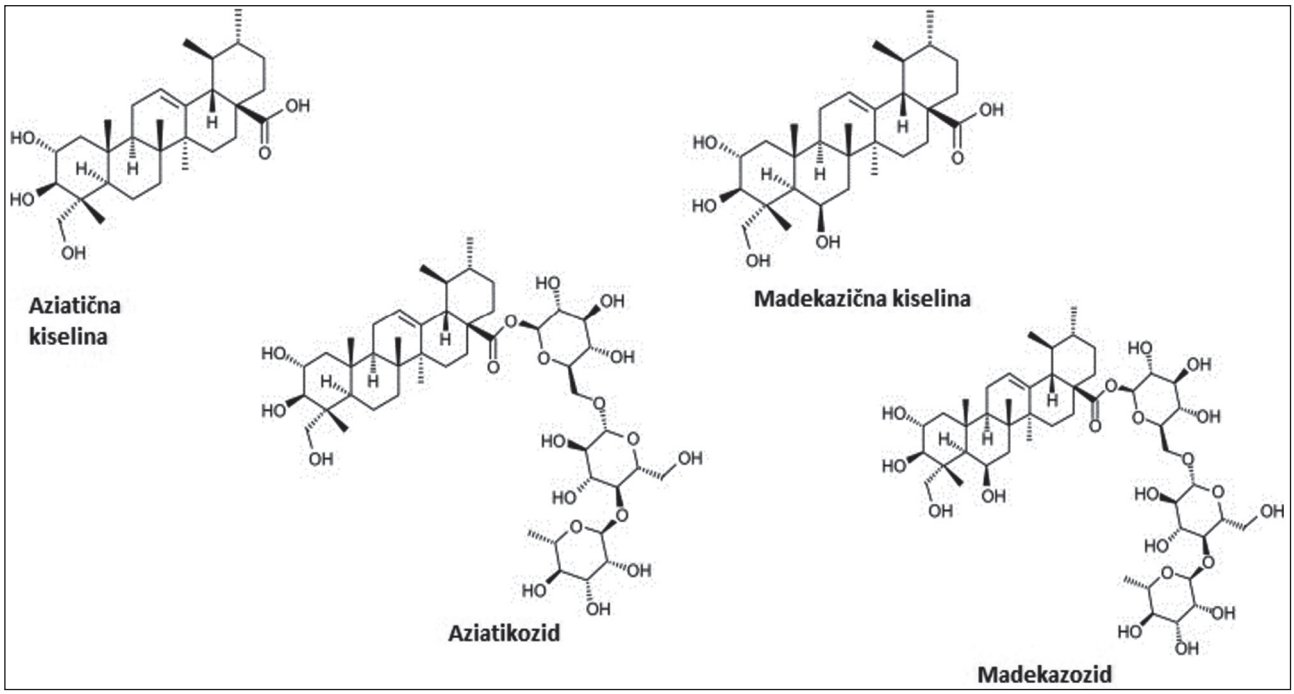

Figure 3. Main substances found in C. asiatica [8]

Alkaloids (hydrokotiline); Glycosides (asiaticoside A, asiaticoside B, and madecasoside)- hydrolysis of these substances form the corresponding triterpenoid acids; Fatty acids (stearic, palmitic, lignoceric, oleic, linolic, and linoleic acid); other components (campherol, quercetin, stigmasterol, sitosterol, campesterol, polyacetylene, carotenoids, vitamin B, vitamin C, and other sugars and alcohols).

Ursan and oleane type oligoglycosides like centelasaponins B, C and D have also been isolated from over ground parts of the plant together with madecasoside, asiaticosid B and skefeloside A.

Three of the most important pharmacologically active substances are pentacyclic triterpenes: asiatic acid, madecasoside and asathioside. In one study [9] a method for a qualitative evaluation using HPLC of the *C. asiatica* extract was presented, where "fingerprints" are the ones that show the presence of asiatic acid, madecasoside and asathioside.

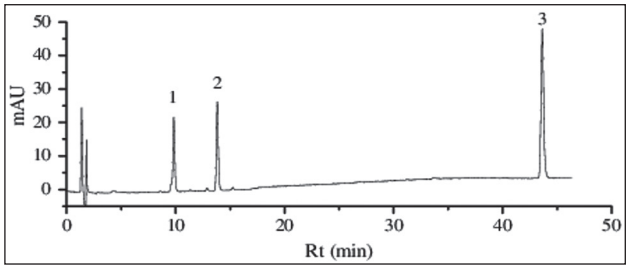

Figure 4. HPLC chromatogram of C. asiatica [9]

Antimicrobial properties

C. asiatica has mild antibacterial properties. In a study by Zaidan et al. [10] the in vitro antibacterial activity was investigated using a disk diffusion test of a *C. asiatica* (1mg) methanolic extract, and showed a 5mm inhibition zone on the disk for *Staphylococcus aureus*, compared to 30μg vancomycin which caused 16mm inhibition zone. Additionally, the same extract (1000mg) showed antibacterial activity on MRSA (methicillin - resistant *Staphylococcus aureus*) at 7mm compared to 1 μg of oxacillin which gave 17mm.

Dash et al. tested a petroleum ether, ethanol, water, chloroform and n-hexane extract of *C. asiatica* on *P.vulgaris*, *S. aureus*, *B. subtilis*, *E. coli*, *Candida albicans* and *Aspergillus niger* using a disc diffusion test, and confirmed the mild antimicrobial and antifungal properties of *C. asiatica* [11].

Very few studies have been conducted concerning the hair growth effects of *C. asiatica* despite the use of *C. asiatica* for these purposes for millennia in India. One of the few studies on this topic from 2015 showed that the extract really possesses follicle regenerative effects. The following results were obtained on albino rats in the test of a water-ethanol extract of *C.asiatica* leaves prepared in coconut oil as a base (5% of extract in comparison to 95% of oil).

Table 2. Results of Dash et al. antimicrobial investigation of several C. asiatica extracts [7]

Inhibition zone (mm)						
Bacterium	**Petrolether**	**Ethanol**	**Chloroform**	**nHeksan**	**H_2O**	**Ciprofloxacin10µg**
P.vulgaris	17	17	17	14	11	24
S.aureus	15	17	16	12	8	22
B.subtilis	17	19	12	10	9	26
E.coli	13	16	14	0	11	20

Table 3. Effect on hair length in albino mice [11]

	Drug	**Formulation**	**Hairlength in mm**
Group 1	Drug carrier	Coconut oil	2.1
Group 2	Minoxidl	2% solution	5.09
Group 3	Water-ethanol extract	5% (g/ml) in coconut oil	**3.88**

Table 4. Effect on mean hair density in albino mice [11]

	Drug	**Formulation**	**Hair density**
Group 1	Drug carrier	Coconut oil	1195
Group 2	Minoxidil	2% solution	2529
Group 3	Water-ethanol extract	5% (g/ml) in coconut oil	1676

Table 5. Effect on growth time in albino mice [11]

Group	**Growth initiation time (days)**	**Time for complete growth (days)**
Control	8	24
Standard (2% minoxidil)	6	19
Centella asiatica	7	20

Table 6. Effect on mean hair length in albino mice [11]

Group	**Mean hair length (mm)**
Control	2
Standard (2% minoxidil)	3.5
Centella asiatica	3.6

False Daisy (*Eclipta alba* L., *Eclipta prostrata* (L.) L.)

Eclipta alba is a herbaceous plant from the Asteraceae family which inhabits areas of tropical and subtropical climates. Its traditional Indian name is Bhringraj or Bhringraja which literally translates to 'King of hair', which indicates its main use in the traditional Indian medicine. *Eclipta alba* can grow upright but also straight outward (hence the name for the species) up to 91.5cm in height. Leaves are oval with short toothed margins. The stems are reddish-brown with short, straight and upward-facing hairs. The root is well-developed - cylindrical. The flower heads are 6-8 mm in diameter, solitary (not in groups) and usually white. *Eclipta* has round blossoms that are initially green and then turn white. There are three types of *Eclipta alba* - with white flowers, with yellow flowers and a third with black fruits [12].

Pharmacological properties

E. alba has a variety of different pharmacological properties, and it is used for a number of different diseases. *Eclipta alba* also has many other pharmacological properties including, primarily as a hepatoprotective plant, antibacterial, antifungal, antimalarial, antihyperglycemic, antioxidant, nootropic, hypolipidemic, immunomodulatory and cytostatic.

The active component, 25-beta-hydroxyverazone, showed good activity against *Candida albicans*. In vitro antifungal activity of *E. alba* extract was investigated against *Candida tropicalis*, *Rhodotorula glutinis* and *Candida albicans*, and

had promising antimalarial results against *Plasmodium berghei* in mice [12].

Antibacterial properties

It has been confirmed by several investigations that various components obtained from *E. alba* show a good activity against *Staphylococcus epidermidis* and *Salmonella typhimurium* [12]. Also in strong antibacterial activity of hexanone *E. alba* extract against *S. aureus*, *B. cereus*, *E. coli*, *S. typhi*, *K. pneumoniae*, *S. pyogenes* and *P. aeruginosa* was demonstrated while acetone, ethanol, methanol and aqueous extracts showed an intermediate activity against *S. aureus*, *B. cereus*, *E. coli*, *S. typi*, *K. pneumoniae*, *P. aeruginosa*, *P. mirabilis* and *S. pyogenes*.

Effects of *E. alba* on hair growth and Alopecia

E. alba is one of the best-known plants from Ayurvedic medicine used in hair regeneration, and the latest studies confirm this notion. In a 2009 study it was confirmed that a methanol extract from *Eclipta alba* definitely stimulates hair growth by inducing the anagen phase (growth phase) of hair follicles [5]. In this *in vivo* study on mice, minoxidil 2% and *E. alba* 3.2mg / 15cm2 extract were equally efficient.

In a more recent study, a significant activity of *Eclipta alba* extract was demonstrated in *Foxn1* mutated mice in increase the number of follicles and the density of follicles in the anagen phase which was observed histologically. In addition, new follicles in *Foxn1* mice treated with *E. alba* extract were placed in deeper layers of the dermis compared to mice treated with minoxidil. An increase in keratinocyte proliferation in anagenous hair follicles was also observed. Unlike minoxidil, no dermatological side effects, such as redness, skin dryness or erythema, were observed with the *E. alba* extract. This study clearly and unambiguously demonstrates the superiority of *E. alba* extract in the treatment of alopecia with respect to the conventional vasodilator drug- minoxidil [13]

Unfortunately, the exact substance from *E. alba* extract, which exhibits this beneficial effect, nor the exact mechanism of action or the receptors to which it relates are still unknown. [13]

Chemical composition

Eclipta alba contains a wide range of active substances including cumesters, alkaloids, flavanoids, glycosides, triterpenoids. The leaves contain stigmasterol, β tercienylmethanol, lactolactone, demethylvedelolactone and demethylvedelolactone - 7 - glucoside. The roots contain, amongst others, hentriakontanol and petacosanol. The stem and leaves contain phytosterols, β - amyrins, and luteolin - 7 - glucoside, β - glucoside phytosterols, triterpic acid glucosides, and wederolactones.

Polypeptides isolated from plants contain cystine, glutamic acid, phenylalanine, tyrosine and methionine. Also nicotine and nicotinic acid have been reported. The most important alkaloids are verasine, dehydroverasine and ecliptalbin [12]

Nard (*Nardostachy jatamansi* (D. Don) DC)

N. jatamansi is a small perennial plant from the Valerianaceae family, whose habitat is the Himalayas. It is a well-known Ayrshire plant and is used in various formulations for a number of diseases. The long sessile and oval leaves are 15-20cm long, 2.5cm wide and they are gradually narrowed from the base of the leaf. The flowers are light blue or pink. The rhizome is elongated, darkish, crowned with reddish-brown fibers and reaches lengths up to 2.5 to 7.5cm. The plant itself reaches a height of 10-60 cm.

In addition to being used in alopecia treatment, *N. jatamansi* is also used to improve cognitive and neurological functions. Jatamansi essential oils possess antiarrhythmic activity, and are used to improve the flavor in preparations of certain medical oils. The essential oil is extremely beneficial for smooth, shiny and healthy hair. It has a protective effect in epilepsy, cerebral ischemia, liver damage, and in some mental disorders. It is also used as a carmine, spasmolytic, and against palpitations.

Jatamansi essential oil fungicidal activity was found against *Aspergillus flavus*, *Aspergillus niger*, *Fusarium oxysporum*, *Mucor fragilis* and *Rhizopus stolonifer*. In a recent study that tested the antimicrobial activity of aqueous, hexane, chloroform, n-butanol and dimethylsulfoxide extracts of *N. jatamansi* rhizomes against *S. aureus*, *P. aeruginosa*, *S. typhimurium*, *S. aureus* and *M.*

luteus by agar diffusing head found a profound antimicrobial activity against all investigated strains. In fact, butanol and hexane extracts had the strongest activity [14].

Additionally, it was found that the oral administration of the ethanolic extract of *N. jatamansi* increases the level of serotonin and its metabolite 5-hydroxyacetic acid (5-HIAA) in rats, which may explain the effect of Nard as an antidepressant. Also in the same study, an increase in GABA has been demonstrated, indicating sedative and antiepileptic effects of this plant.

The following constituents have been isolated in nard: alpha-pachoulenes, nardostahisin, angelicin, beta-eudesmol, beta-pachoulenes, beta-sitosterol, kalarenol, kalarenol, elemol, jatamansi, jatamansinol, jatamanson, n-hexacosan, n- hexacosanil arachidate, n-hexacosanil isolverat, nardol, nardostechon, norsechelanon, oroselol, pawuli alcohol. There were also sesquiterpenes: spirotamine, nardin, nardal, mantle amine, b-malin, gamamol A and B, calarenol, and coumarins: xanthogaline. The presence of the alkaloid actidine was also confirmed, while nardal is considered to be the main active substance.

In a recent study on mice, a positive effect of the Nard hexane extract, used topically, on the rate of hair growth, was demonstrated. During this study the whole extract as well as different fractions were investigated (3 fractions were obtained by chromatographic separation of the complete extract), where the first and the second showed a positive effect, and the third one did not. Minoxidil was used as a control substance. Nardin, Nardal, and Jatamanic acid were confirmed to have the strongest effect, and subsequent tests showed that a combination of these three substances had a pharmacological effect, though to a lesser degree than minoxidil [15].

Coco-grass *(Cyperus rotundus L.)*

Cyperus rotundus is a monocotyledonous perennial plant from the Cyperaceae family. It inhabits mostly dry areas (though it can be found in certain wetlands) tropical, subtropical and moderate areas in Asia and Europe. It has a long rhizome in an ellipsoidal form, sometimes resembling a bulb, which is black, with a characteristic aromatic odor and taste, up to 60cm long. The leaves are long 5-20cm wide and 2-6mm wide. The layout of the leaves on *Cyperus rotundus* is cyclic with the same node carrying three leaves which, unlike other grass species, where the same node carries only 2 leaves. The individual flowers are small, unobtrusive, 1.27-5.08 cm long, and emerge in a group of 12-30 from the top of a flower handle, purple or bushy brown. Each flower carries one fruit (achene).

Active substances

Cyperus rotundus essential oil contains 98 different types of molecules. The most commonly found constituent found using GC-MS analysis is, cyperene (9.76%). In addition to cyperene there are also humulens (7.97%), beta-selenium (7.88%), zieron (4.62%), camphenal aldehyde (3.83%), alpha-pinen (3.51%), longiverbenone (2.72%),) (1.45%), limon (1.45%), terpineol (1.55%), azulene (1.35%), alpha selenium (1.29%), mylenol (1.25%), caluria (1.66%),), isogermacrene D (1.17%) and isologifolene (1.04%) [16].

Pharmacological effects

C. rotundus exhibits anti-inflammatory, anticonvulsive, antioxidative, antidiarrhoeic, cardioprotective, antiallergenic, antihypertensive, and anticonvulsive effects. In fact, the anticonvulsive properties are believed to be due to the inhibition of voltage-dependent Na^+ channels, by blocking glutaminergic excitation induced by the N-methyl-D-aspartate (NMDA) receptor, by decreasing Ca 2+ channel activity, or by agonizing GABA-A receptors.

Additionally, antimicrobial effects were observed. In a 2016 study, a mild antimicrobial property of *C. rotundus* extract was shown. Petroleter, ethanol, water and chloroform extracts of *C. rotundus* on *S. epidermidis*, *B. cereus*, *P. aeruginosa*, *E. coli*, *A. niger fungi* and *C. albicans* were used. The most efficient extract was an ethanol extract, and the most sensitive bacterium was *P. aeruginosa*, while *E. coli* was the most resistant. None of the extracts showed antifungal activity against either *A. niger* nor *C. albicans* [17].

Recent studies have confirmed the highly stimulating properties of *C. rotundus* rhizome extracts on hair growth. In one of them a water-ethanol extract

of *C. rotundus* in coconut oil as a carrier (formulation: 5% extracts and 95% coconut oil) was applied on depilated albino rats. The results showed that hair regrew faster in the group treated with the *C. rotundus* extract compared to the minoxidil and control groups (4,6% for the extract, 3.5% for minoxidil, and 2% in the control group). Hair density was also investigated with the following results: 1195 for control rats; 2657 for the extract group; 2529 for the minoxidil group. The study confirmed the efficiency of the *C. rotundus* extract compared to minoxidil. In addition, the extract had no irritating effect on the skin unlike minoxidil [18].

It has been noted that the topical application of the *C. rotundus* essential oil significantly removes unwanted hair. This applies to androgen-dependent hair (on chin, mustache, axillary, pubic region, etc.). The magnitude of activity in several previous studies has confirmed approximately the same amount of epilation efficiency compared to the standard Alexandrite laser for epilation. In a recent study, there was evidence of the same uniformity of hair removal with Alexandrite laser and *C. rotundus* essential oil for removal of black hair, while the essential oil was more efficient in removing white hairs [19].

The mechanism of action on androgen-dependent hair is based on the antiandrogenic action of *C. rotundus* itself; since it has already been shown that certain flavonoids and lignans from this plant act as inhibitors of 5-α-reductase, thus preventing the formation of dihydrotestestenes.

Brahmi (*Bacopa monnieri* (L.) Pennell)

B. monnieri is a small vine from the Scrophulariaceae family, with numerous twigs, small leaflets and light - purple or small and white flowers, with four or five petals. The leaves are oval and fleshy (thickness 4-6mm). The plant is predominantly found in swampy areas throughout the Indian subcontinent.

Active substances

The main chemical ingredients of *B. monnieri*, which are responsible for the nootropic effects, are branched types of triterpenoid saponins, known as the bacosides, with jujubogenin or pseudo-jujubogenin aglycone units. Bacosides make up a family of 12 known analogues. Newer saponins called bakopazides I-XII have been identified recently. The alkaloids brahmin, nicotine and herpestin are also present together with D-mannitol, apigenin, hersaponine, then mononazidides I-III, quinurbitacin and plantainozide B.

Pharmacological effects

Bacopa monnieri possesses fascinating neuropharmacological properties which are increasingly being investigated. Its neurological effects were first demonstrated in a 1999 study of a *B. monnieri* extract on rats. Cognitive deficits were induced by injections of ibotenic acid in the nucleus magnocellularis and with intracerebroventicullar injections with colhicin. After applying a standardized dose of bacoside rich of *B. monnieri* extract, a remission of cognitive deficits was observed [20].

In a recent study, it was suggested that bacosides induce membrane deforphilization with the accompanying increase of protein turnover in specific brain structures (21). In another work of the same author and different co-authors it was suggested that *B. monnieri* enhances protein kinase activity in the hippocampus, which can also contribute to the nootropic activity by repairing damaged neurons by increasing protein kinase activity, and neuronal synthesis and restoration of synaptic activity and neural transmission [21].

Anti-ulcer, antiallergenic and bronchodilatory activity, antineoplastic, analgesic, anti-inflammatory, and antimicrobial effects were also confirmed.

It was found that a methanol extract of *B. monnieri* showed a significant inhibitory effect against leading pathogenic bacteria: *Bacillus subtilis*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Escherichia coli*, *Proteus vulgaris*, *Proteus mirabilis*, *Salmonella typhi* and *Vibrio cholerae*. It also showed inhibitory effect against *Candida sp*.

Additionally, a number of studies on the effects on hair growth have been conducted. In one of them from 2007 [22] it was shown that *B. monnieri* in the examined range of 1-10% concentration showed a positive effect. Herbal formulations containing the plants: *Emblica officinalis* (7.5%), *Bacopa monnieri* (7.5%), *Trigonella foenumgraecum* (7.5%) and *Murraya koenigii* (5.0%), obtained by decoction of these plants in coconut oil showed a faster hair growth effect compared to minoxi-

dil. What is even more interesting is that the total number of follicles in the anagen phase (growth phase) after treatment with this formulation was 62% compared to standard minoxidil, while in the telogen phase (decline phase) there were 17% follicles compared to minoxidil where the follicle in the telogen phase it was twice more - 32%.

Amla (*Emblica officinalis* Gaertn., *Phyllantus emblica* L.)

Emblica officinalis is a small to medium sized tree, (8-18m, in rare cases up to 30m) from the Phyllanthaceae family with a thin, light-colored bark that peels in small thin uneven leaflets. Its leaves are small and light green in color (3mm wide and lengths of 1.25-3cm). Small, unobtrusive, greenish flowers are found in compact clusters in the lower pits of the lower leaves. The fruits are light green before maturation, and become white or yellowish when ripe. The fruits are hard on touch, astringent, extremely acidic while some are spicy.

It is naturally found in subtropical and (to a lesser degree) tropical areas – mainly in India, Bangladesh, China, Malaysia, Pakistan and Sri Lanka at an altitude of up to 1800m.

Active substances

The fruit of *E. officinalis* is one of the richest natural sources of vitamin C (200-900mg / 100g). Many fruits have, for example, a 30% higher vitamin C concentration than pure orange juice [19]. The fruits of *E. officinalis* contain 28% of total tannin distributed throughout the plant. The fruit contains two tannins: Emblicanin A and B with distinct antioxidant effects. The product also contains filemblin. Of tannins there are also puniglukonine, pedunkulagin, hebulinsulfonic acid, korilamin (eligatanin), geraniin (dehydroelagitanin) and elagotanine [23].

Notable alkaloids include filamentin, filembein and filantidine, while the phenolic components are gallic acid, methyl gallate, elagic acid and trigalail glucose [23]. In addition, *Emblica* contains carbohydrates, pectines, flavanoids, and minerals like Zinc, Copper, Magnesium, and others.

Pharmacological properties

Confirmed pharmacological effects and uses include, among others, antioxidative, cardioprotective, anti-inflammatory, immunomodulatory, antidiabetic, antidiarrhoeic, nephroprotective, nootropic, induction of wound healing, hepatoprotective, and antimicrobial [23].

In fact, one study investigating the antimicrobial properties of *E. officinalis* extract confirmed some significant antimicrobial properties against the following bacteria: *Serratia marcescens*, *Bacillus cereus*, *Pseudomonas aeruginosa* and *Escherichia coli*. From the investigated extracts (hexanes, water, methanol and ethyl acetate extract), the best effect was observed by the ethyl acetate extract with the exception of *E. coli*, where the water extract was more effective [24].In another study from 2007, the antibacterial effects of the *E. officinali*s water extract against *Escherichia coli*, *Klebsiella pneumoniae*, *Klebsiella ozaenae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella paratyphi* and *Serratia Marcescens* were demonstrated [24]. In conclusion, *E. officinalis* has strong antimicrobial properties, and their usage in a medical setting should be further investigated.

Almost every polyherbal formulation prepared according to ayurvedic principles and intended for treating alopecia contains *E. officinalis*. In several studies this activity has been confirmed, and even some mechanisms of action have been found. Furthermore, the essential oil was found to have an inhibiting activity on the enzyme 5α-reductase activity which was comparable to finasteride [23].This explains its positive effects on androgenic alopecia.

It also slows down the hair whitening process. *Emblica officinalis* is accepted as a hair toner in traditional hair growth enhancing recipes. The fruit, cut into pieces, is dried in the shade if possible. Then these parts are cooked in coconut oil until the hard material becomes charred. The frequent topical use of such a dark oil is excellent in postponing (slowing) the emergence of gray hair. In another study it was found that *Emblica officinalis* stimulates the proliferation of dermal papillary cells in a concentration-dependent manner suggesting its role in promoting hair growth.

3. Conclusion

Until now, no detailed chemical analysis has been published for any polyherbal formulations for hair growth. In several studies an analysis of the efficacy of some polyhydric formulations applied in Ayurvedic texts was carried out and fantastic results were obtained - with an approximate or stronger effect compared to the standard minoxidil. However, the chemical analysis of a whole polyherbal formulation is absent.

The aforementioned plants have shown to contain a variety of active substances including, triterpenic acids, unsaturated and saturated fatty acids, alkaloids, glycosides, amino acids, organic acids, lignans, oligosaccharides, terpenoids, oligoglycosides, saponines, triterpenes, kumestans, flavanoids, phenols, polypeptides, sesquiterpenes, vitamins, minerals and others.

All of these plants showed a significant positive effect in at least one of the in vivo studies. This effect was expressed by increasing hair growth rate, increasing hair density (number of follicles), increasing follicle size, and most importantly, they showed a drift from telogen to anagen. This last effect, on the example of *Eclipta alba* in one study, was approximately equal to minoxidil, while in another it was even stronger than minoxidil. In addition, extracts of all these plants have shown to have moderate or pronounced antibacterial activity against at least a few species of bacteria pathogenic for humans.

All of these data suggest that the aforementioned plants and formulations made from the same promise, perhaps in the future, the identification of novel substances which will have a much stronger antioxidant effect compared to minoxidil and having very little undesirable side effects. In addition, they also carry a significant antibacterial potential that should be profoundly investigated in the future.

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Incorporating intelligent flashcards for fostering EFL learners' vocabulary knowledge: The case of Anki Software

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Abstract

The primary purpose of this study was to explore the possible effect of using intelligent flashcards on learners' vocabulary improvement. Research was conducted in an English Language Learning Institute with a group of forty one ELL students and focused on TOEFL vocabulary development. The students used the Anki application to study 20 new words every day during the three week intervention process. Pretest and posttest scores of students were compared to evaluate the effectiveness of the learning process. The results of the paired-samples t-test and effect size revealed that learners outperformed in their post-test as compared with their pre-test. Learners were able to do the entire study skill activity at their own pace and time using their own learning styles and strategies and receive immediate feedback on their learning. The findings present the benefits that might be gained from the integration of flashcard programs into a language classroom and call for teachers to create learning environments that incorporate technological tools to develop vocabulary.

Key words: vocabulary, flashcard, Anki, technology, language learning

1. Introduction

It goes without saying that vocabulary knowledge is an indispensable part of learning a language and communicating ideas and feelings. Lack of vocabulary knowledge or misuse of words can result in misinterpretation and break down communication. According to Krashen

Vocabulary is basic to communication. If acquirers do not recognize the meanings of the key words used by those who address them, they will be unable to participate in the conversation. And if they wish to express some ideas or ask for information, they must be able to produce lexical items to convey their meaning [1].

Words, according to Schmitt, Wesche and Paribakht, do not stand alone; they are units with strong and complicated features [2,3]. The importance of learning vocabularies lies in the fact that words do not stand alone; they are units with strong and complicated features. Knowing a word involves knowing its frequency, collocability, limitations of use, its semantic value, different meanings, syntactic behavior, underlying forms and derivations, and its place in a network of associations with other words in the language [4]. There is an agreement on the importance of vocabulary acquisition in learning. Neuman stress that "vocabulary development was an integral part of school readiness, a reference to the motivational behaviors and the common knowledge and experiences that are necessary for children to enter into school meaningfully"[5]. In other words, empowered vocabulary base motivates learners in their learning and helps them understand and face their lessons in a way which makes sense to them. Vocabulary knowledge assists learners to go through their education with minimum difficulty and execute deeper cognitive processing. Moreover, it assists learners to express themselves more distinctly, and to find out things more rapidly. It may not be a surprise to say that with strong vocabulary base learners can read more and consequently learn more. Tokac states that "often, students cannot understand an English text well or a person who is talking to them in English because of insufficient vocabulary knowledge[6]. Sometimes students cannot express themselves effectively simply because they do not possess the needed vocabulary

for successful communication" In line with Information-processing Theory in second language acquisition, lexical knowledge play a significant role in learners' language learning inasmuch as words lead to activation of the appropriate schemata a prerequisite for comprehension [7].

According to Kilickaya and Krajka, vocabulary teaching is "generally restricted on presenting new items as they appear in any activity without preparing the learners through activation of prior knowledge or helping them regularly revise the previously learned vocabulary items until they are thoroughly learnt" [8]. One recent attempt to boost learners' vocabulary knowledge has been the use of technology in language learning. Thanks to the technological breakthrough, language learning has embraced a new form of learning which is beyond its traditional form. Technology provides various types of content, such as text, audio, video, graphics, animation, and interactivity to generate, communicate, and negotiate meaning. Nowadays, learners have easy access to the technology to share ideas, collaboratively work with other learners, and understand information. According to Sharifi, Azizifar, Jamalinesari, and Gowhary, computer-assisted language learning furnishes learners with "easy access to learning environments irrespective of place and time, and increases motivation and effectiveness of learning with multimedia content [9]. Additionally, it can help learners to study language individually at their own pace in a motivated atmosphere with a high level of interactivity". It should be noted that technology can effectively be used for the presentation, reinforcement and assessment of the content which is going to be learned, while accompanied by a significant interactive element. Computer programming further enhances the retreivial practices in vocabulary learning [10]. Barani stated that computer "forces pedagogy to think in new ways to exploit the computers benefits and work around its limitations"[11]. In terms of affordances of technoogy, Klopfer and Squire discussed five advancements including: (1) portability—mobile devices can be easily carried and used anywhere, (2) social interactivity—mobile devices can be used for collaborative work, (3) context sensitivity—mobile devices affords authentic contexts, (4) connectivity— mobile devices are connected to other devices through an array of local and cellular networks, and (5) individualizing instruction—apps on personal devices can provide user-specific scaffolding based on individual preferences and personal learning progress[12]. Mobile learning activity increases digitally-facilitated activities in order to own and control what you learn. As a result, students face with new opportunities for individualized learning and practice. In this regard, the present study aimed to explore the implications of using a mobile application, namely Anki, in improving learners' vocabulary knowledge. The study, thus, sought the following question

Is the use of Anki application effective in improving advanced learners' TOEFL vocabulary knowledge?

2. Literature Review

Among different technologies which have come to help learners, one can refer to mobiles, iPads, and tablets. According to Abbasi and Hashemi, mobiles and tablets are used three times more than personal computers[13]. That is to say "a common mobile learning activity could build in more opportunities for digitally-facilitated activities and for ownership and control over what learners do" [13]. Therefore, mobiles have created a potential platform to enhance learning and teaching. This has led to the new era of 'Mobile Learning' or M-learning. M-learning has paved the way for "a new type of learning model which allows learners to receive learning materials anywhere and anytime through wireless telecommunication network and the Internet"[14]. M-learning merges strategies, practices, applications, and resources accompanied with advanced technology to promote learning.

Out of the applications introduced for learning vocabularies, Anki is one of the most frequently used ones. According to Godwin-Jones, Anki is one of those flashcard applications that has been increasing its users and introduced as a more practical program, presenting its users with different options as compared with other existing flashcard applications[15]. Anki is an intelligent flash card program which supports images, audios, videos, and scientific markup. By the help of Anki, users can decrease the time they spend learning words, and accordingly increase the amount they learn.

Anki provides access to numerous numbers of free flashcards called *decks* on different categories and classifications of vocabularies and learners can create their own decks on different classifications e.g. essential IELTS words. It's principally based on a paper flashcard system with the target word on one side and the answer on the back. Nonetheless, the appearance of Anki does not look like the paper flashcards (see Figure 1). Altiner summarized the advantages of using Anki as the followings:

a. With Anki, word cards can be designed in a variety of ways and different options such as pictures, graphics, and pronunciation of words can be added to them.
b. Different from other flashcard programs, Anki is much more flexible and it provides users with the opportunity to change the directions of the word cards easily and create various kinds of cards.
c. Instead of creating their own cards, users can also import ready-made card decks into their Anki program and start reviewing the cards right away. It is also possible for users to share their own card set with other users.
d. Another good feature of anki is that learners can access their card decks with free online website by using desktop syncing or using it with their mobile phones[16].

Regarding the effect of m-learning, studies have reported the significant impact of mobile phones and mobile applications on learners' vocabulary knowledge. In one study, Agca and Özdemir explored the effect 2D barcode technology on learners' vocabulary learning[17]. The definitions and images related with the words in the learners' course book were presented in mobile learning environment. The results of pre- and post-tests revealed that students benefited from m-learning and the application helped them to easily learn the words in their course book. In another study, Abbasi and Hashemi used SMS to study the effect of m-learning on learners' vocabulary retention. While learners in control group received the activities on the paper at once, the learners in experimental group received them via mobile phone by sending and receiving SMS within a time duration of one day[13]. The experimental group were asked to answer the multiple-choice exercises via SMS. The results of the study showed that mobile learning had significant effect on learners' vocabulary retention. The similar studies reported that the use of SMS provided the chance to practice and work on vocabulary learners had to learn [18,14]. According to Hu, using text message as a tool for delivering new words "allows learners to be exposed to the distributed vocabulary items on the regular basis, which can be a complementary approach to massed vocabulary learning, as in the traditional paper-based vocabulary learning" [19].

3. Method

Participants

Forty one advanced female learners learning English as a foreign language participated in the study. Learners were preparing for TOEFL exam (Test of English as a Foreign Language). Prior to the study, the researchers administered First Certificate in English (FCE) to check learners' language homogeneity. Then, the researchers administered Vocabulary Size Test to see if there were any significant differences among them with respect to their vocabulary knowledge. The learners were between 20 and 29 years of age, with the mean of 26.

Instruments

Four tests were used as the instruments in this study. The first instrument First Certificate in English (FCE) was administered before recruiting participants. The test is developed by Cambridge English Language Assessment and assesses the four language skills i.e. reading, listening, writing and speaking. The first part includes 56 questions for reading and writing, the second part contains 25 questions for listening, and the last part assesses learners' speaking ability. Regarding the validity and reliably of FCE, Cambridge English Language Assessment Center reported a high validity and reliabilities of 0.8 and above for the test. The second instrument was Vocabulary Size Test designed by Nation and Beglar [20]. The test includes 140 multiple-choice questions. The researchers selected Nation's Level Test as their reliability has strongly been proved and they have mostly been cited in numerous articles.

The thitd and fourth instruments were TOEFL vocabulary test. In order to test learners' vocabulary knowledge before and after the intervention, two vocabulary tests adopted from *Barron's Essential Words for the TOEFL* (6th ed.) written by Matthiesen were administrated as pre- and post-tests. Each test consists of 30 multiple-choice questions[21]. The Cronach α of the tests were calculated and reported as .81 and .75, respectively.

Procedure

This study was designed to adopt an intelligent flashcard application, Anki, as a tool to study learners' vocabulary development. The learners

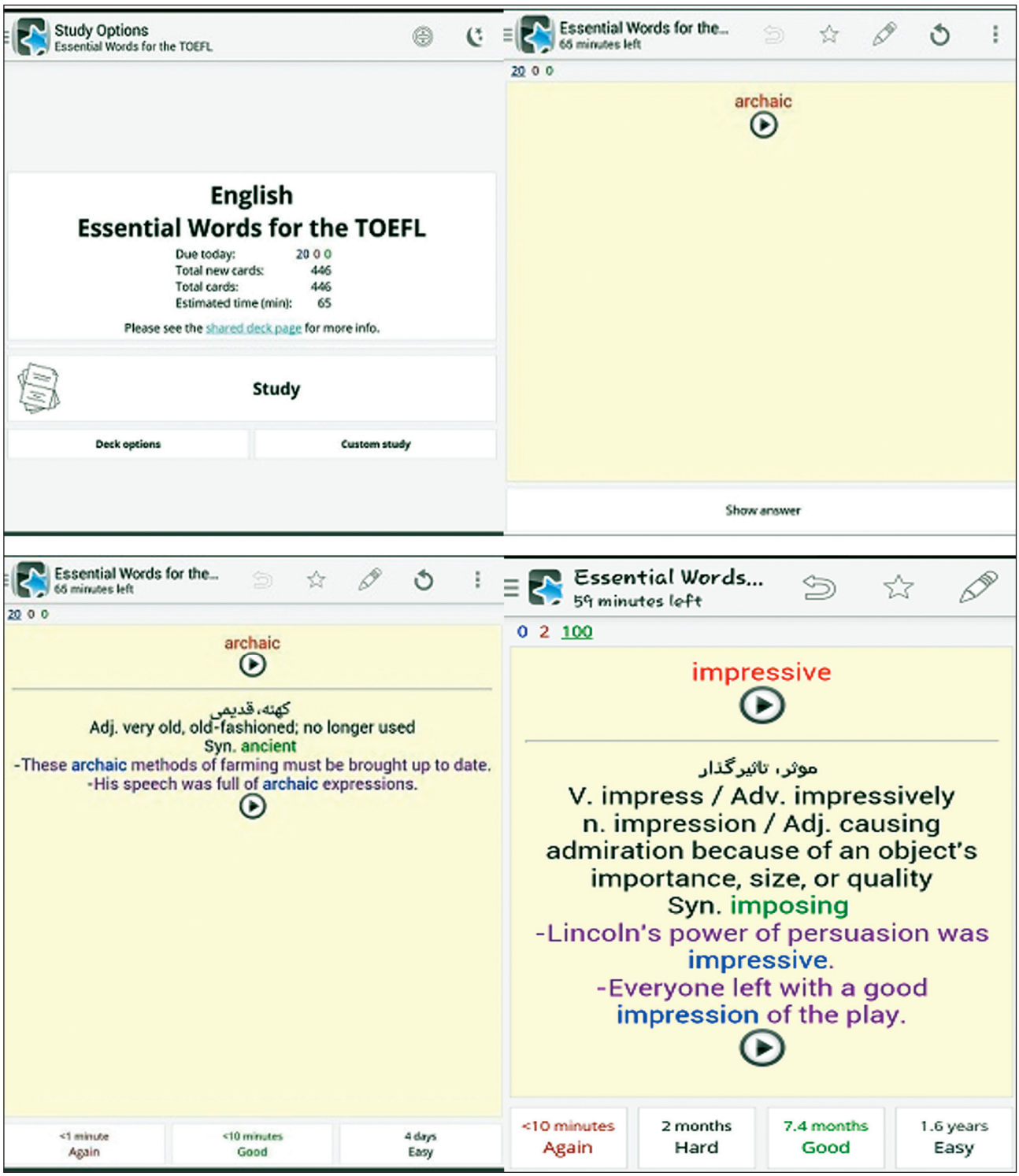

Figure 1. Screen shots of the Anki Flashcard

participated in their regular classes three times a week and worked on *Mosaic 1 Reading* written by Wegmann and Knezevic [22]. The Mosaic 1 is a well-known book in Iran used in English institutes and universities. The book has flexibility and ease of use, the texts are accompanied with a variety of skill-building practices, lively activities, and interesting and practical information about life. As part of their home assignment, learners were asked to study the assigned new vocabularies by using Anki application every day.

Prior to the study, the researchers checked learners' language proficiency and vocabulary knowledge. After making sure that learners were homogenous, the researchers administered a pre-test to have enough evidence on learners' performances before the treatment. Learners were requested to download the free application of Anki on their smart phones, iPod, or tablets and set up Essential Words for the TOEFL deck in their Ankis. The deck consists of 446 words which are necessary for TOEFL test. In using Anki, first the word is pronounced for the learners, then by touching show answer the different part of speech, synonym, examples, and the Persian meaning of the word are displayed (see Figure 1).

If learners know the meaning of the word, they can select one day or four days interval for rereading the word. If they do not know the meaning of the word, they can select 10 minutes option and the unknown words are reshown to the learners as they are learning or practicing new and familiar words. This process is repeated and repeated until learners learn the meaning and use of the new vocabularies. In this way, in day 1 learners would read and repeat 20 new words. In day 2 they should work on 20 new words as well as practice the vocabularies they had studied in the previous day and set to study in the following day. The application also shows the total time required to study the due cards of each day (e.g. 65 minutes left as shown in Figure 1). The three numbers on the top left side of the page inform important message: the number in blue shows the total number of words that should be studied in that day, the number in red shows the total number of words that are being repeated from the cards of that day, and the number in green shows the total number of words should be studied from previous days. Over 22 days, this process was repeated until learners learnt all the target vocabularies. Following the completion of the deck, learners participated in a post-test for checking their vocabulary knowledge. Paired-samples t-test and effect size were calculated to analyze data.

4. Results

Regarding the objective of the study, learners' performances before and after the treatment were analyzed. Table 1 shows the descriptive statistics of learners in pre- and post-tests. According to the results, learners enjoyed higher mean in their post-test (M=25.36, SD=3.29) as compared with pre-test (M=19.40, SD=5.56) denoting that using Anki flashcard helped them to promote their vocabulary knowledge.

Table 1. Descriptive statistics of learners' performances in pre- and post-tests

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	19.40	41	5.56	.86
Post-test	25.36	41	3.29	.51

However, to check the significance of the differences, the paired-samples t-test was run. Based on the results, there is significant difference between learners' pre- and post-test vocabulary knowledge (t (40)=-8.35, p=.00). It can be mentioned that learning words by the help of Anki application considerably enhances learners' vocabulary proficiency and helped learners to learn and remember more vocabulary. The effect size of the impact is also at very high level (Cohen's d=1.30). This pinpoints a dramatic improvement as a result of mediation on the learner's scores.

With reference to the results of the study, it can be argued that Anki flashcards help learners to gain greater amount of vocabulary in a short span of time. Learners practiced 446 essential TOEFL words over three weeks and their scores improved meaningfully. It is worth mentioning that although the use of Anki influenced each learners' success at different rates, all learners scored at least 20 out of 30 which denotes that they master more than half of the vocabularies.

Table 2. The results of paired-samples t-test

	Paired Differences			t	df	Sig. (2-tailed)	D
	Mean	Std. Deviation	Std. Error Mean				
Pre-test – Post-test	-5.96	4.56	.71	-8.35	40	.000	1.30

5. Discussion and Conclusion

The primary purpose of this study was to explore the possible effect of using Anki application on learners' vocabulary development. 41 advanced learners of English as a foreign language participated in the study. The learners were preparing for TOEFL exam and worked on Mosaic book. After checking their homogeneity in terms of language proficiency and vocabulary knowledge, learners participated in a pre-test exam. The treatment included the use of Anki application to learn and remember 446 essential TOEFL words. After three weeks, learners participated in a post-test exam. The results of the paired-samples t-test and effect size revealed that learners outperformed in their post-test as compared with their pre-test. According to the findings, Anki program was beneficial in increasing learners' vocabulary knowledge. Altiner discussed that Anki is proved to be useful "in terms of keeping the record of learners' improvement for a certain amount of time and arranging the order of words which enable learners to see and practice difficult words more often[16]. By using Anki, learners did not spend time arranging review schedules". Anki planned the reviewing process and presented the vocabularies in an organized manner based on the review options selected by each learner. Moreover, the definitions, examples, images and etc. accompanied with each word speeded up the learning process and retention in long run.

Previous studies on vocabulary learning also reported similar results [17,9,14]. According to Agca and Ozdemir [17], learners outperformed in the post-assessment of their vocabulary learning. It is indicative that mobile learning provides the advantage of learning with images and definitions which ease learning process. Sharifi et al. [9] and Pahlavanpoorfard and Soori [8] argued that computer software on vocabulary allow learners to have control over their learning process and manage the pace of their learning. In this way, as it can be seen in this study, learners become motivated to learn and the motivation facilitates learners' vocabulary learning. Direct observation of learners' using mobile applications on vocabulary learning further proved that in mobile environment learners need less direct teacher participation and they can take responsibility of their learning [23]. Başoğlu and Stockwell laso found that digital flashcards outperformed traditional flashcards on paper [24,25]. According to Suwantarathip and Orawiwatakul, "mobile phones can build learning environment where students can study anywhere and anytime[22]. They had flexibility in how long they would devote to the given assignments and when they did them" . Therefore, the traditional boring learning is replaced with a constant and distributed learning which has more favorable effect on memory and learning. The finding can be supported by Ushioda who stated that "autonomy, flexibility, freedom and choice are intrinsic features of mobile learning, and by exploiting these features may well be able to promote internalized motivation for independent learning" [26]. Altiner discussed that learning vocabularies through Anki is promising for in terms of

a. giving learners a chance to organize their vocabulary learning based on the spaced repetition,
b. language teachers can integrate a recycling process into vocabulary learning by means of Anki,
c. the spaced repetition helped academically oriented college-level students improve their academic vocabulary and changed their negative perceptions about vocabulary learning, and
d. learners found Anki useful, usable and enjoyable[16].

Therefore, curriculum developers and instructors should be aware of the potential of this application and encourage learners to use it.

Regarding the development of learners' vocabulary knowledge, Anki has significant implications to be incorporated in syllabus and used in classroom. First, Anki is a free programmed application that can be downloaded and run in all types of mobile operating systems e.g. Android, IOS and computers. Learners do not have to worry about any extra fee or charges for using the application. Moreover, it is an off-line program and can be used anywhere at any time and learners do not longer need to be connected to the internet. Therefore, learners have access to vocabularies out of the classroom hours and accordingly academic achievements can be increased more. In general, it is agreed that Anki was easy to use and learners do not have serious technical problems [16].

Second, Anki application and the similar programs proved to be innovative and funny in learning vocabulary. Rezaie et al. discussed that "mobile learning environment created curiosity for students and made the vocabulary learning activity more attractive with motivating them in positive way"[23]. It should be noted that leaners have always been concerned about learning vocabularies since learning vocabulary is both a difficult and boring process. However, teachers can change negative attitude toward learning vocabulary by integrating, adopting, and adapting such applications into learning and teaching similar to this study. Importantly, the one to one interaction between the learner and the application promoted individualized learning in which the learner actively participates in the learning process, take the responsibility of learning, and work at their own pace. The learner received instant and individualized feedback and have the chance to correct his/her mistake. This, as a result, decreases affective filter and contributes to future successes.

Third, the pronunciation, definitions, part of speech and examples presented by each word help learners to build better mental images and association which facilitate learning. It removes the need to teachers in learning and teacher-led instruction. Learners are able to customize their learning and make vocabulary goals easier or more difficult. For example, learners can increase the daily vocabulary practices from 20 words per day to 50 words per day or develop their own deck e.g. English irregular verbs. Learners can also share their decks with other learners around the world and use theirs. Moreover, learners have flexibility in how long they would allocate to the given assignment and when they do them.

Generally speaking, nowadays mobile phones have become an integral part of learners' life which closely fit their habits. This ease of access and use has changed mobile applications, particularly Anki, to fruitful learning activities in and out of the classroom. Learners can do the entire study skill activity at their own pace and time using their own learning styles and strategies and receive immediate feedback on their learning. Being autonomous is one of the significant advantages of m-learning. According to Lu, mobile phones can be "an alternative instructional tool for learners of special needs or complementary teaching material that offers multiple learning opportunities". However, in designing m-learning adjusted pedagogy including choosing activities that fits students' needs, situated, personal, collaborative and long term activities, the appropriateness of activities, and the readiness of learners' learning tools should be considered. These features can affect the success of language learning development. Instructors should have their learners pay attention that these kinds of programs are accessible for their vocabulary learning. Respecting the future studies, there is a need on investigating the learners' long-term response and vocabulary retention. Qualitative data will also add to the richness of the use of mobile applications in language classes.

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A statistical study on educational development index for literacy paramaters of India

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Abstract

India faces the big problem of unemployment, improper trainer and worker, underemployment and unequal distribution of wealth today. These entire problems occur because of low literacy and illiteracy of India. Education is important factor in social economic development to maintain the economic inequality and low income disparity. In this paper we have consider six literacy parameters like General male, female, Schedule castes male, female and Schedule tribe male, female and analyzed literacy variations among different location, region, sex, castes of India. Considering these six parameters we compared the Educational Development Index (EDI) using statistical techniques viz. principle component analysis, composite variable rank and growth index.

Key words: Literacy rate, Principal component analysis, Composite variable index, Growth index.

1. Introduction

In world, education is considered as the fundamental element for national development. Literacy is important for national and individual levels. At the national level, a literate population is required to construct a nation with strong social, economic and political foundations. Literacy is an important starting point that brings awareness in people to work towards a better living and at an individual level; it reduces poverty, improves quality of life, helps to attain gender equality and ensures peace, democracy and sustainable development [1]. Literacy plays a significant role in the calculation of Education Development Index (EDI). EDI calculate growth of development of state, achievement in socio-economic of state and also measure the standards of living, long and healthy life of person [2].

Literacy is main path for social and economic growth in every country. In India, at 1947 the literacy rate was just only 12%. At that time socio-economic growth of India is very low as compared to the other country and India faces big challenge of social, economical and global improvement. After that 2011 census survey, literacy rate goes to 74.04%. Although this seems like a very huge achievement for India. The female literacy levels according to the 2011 census are 65.46% where the male literacy rate is over 80%. Among the Indian states, Kerala has the highest literacy rate and then Mizoram ranks second for literacy rate. Bihar has the lowest literacy rate in India with 63.82% [1].

In rural areas lot of children do not get education due to the economic condition of family. So, the government has to make a law that every child under the age of 14 should get free education. Also, the female literacy rate is very low as compare to the male literacy rate as many parents do not allow their daughter to go to schools. In India, to aware people about education, many NGO's and government advertisement, campaigns and programs are held [3].

This paper attempts analysis of Educational development index by using three different techniques like principle component analysis, composite variable index and growth index of twenty four states of India and some states are not considered such as Arunachal Pradesh, Punjab, Chandigarh, and Nagaland due to unavailability of information. Lastly, literacy levels of all states have been ranked in descending order and comparison of these different raking methods of various states are summarized in table form.

2. Literature review

P. E. Petrakis and D. Stamatakis [4], conducted empirical research, in a pooled data context, to investigate the connection between the growth effect of education and the level of development. The empirical section of this study utilizes the new endogenous growth theory by projecting a

corresponding stochastic model for three alternative country groups, one for each development category, and comparing the coefficient of each educational level among the different development categories.

Zahid Ahmad and Tayyaba Batul [5], analyses and evaluate the poverty and education status in Pakistan. Also discussed on the results of descriptive analysis, unit root test, Johanson Cointegration Test, vector correction error model (VECM), Wald test and Granger causality test carried out on the data of each country for the time period 1971-2011.

Philip H. Brown, Albert Park [6], analyzed household and school survey data from poor countries in six Chinese provinces to examine the effect of poverty, intra-household decision making and school quality on educational investments and learning outcomes. Finally also measure of school quality has some effect on the duration of primary school enrollment but not on learning.

Antonio Villar [7], proposed a multidimensional index that summarizes three relevant aspects of the educational achievements, out of the data provided by the Programme for International Student Assessment (PISA) report, concerning reading abilities of 15-year-old students from 65 countries. The three aspects considered are: performance, equality and quality.

3. Research methodology

I) Source of Data: - For the present study, we considered the data from the 14th and 15th national census survey. The data gathered by the office of the register, general and census commissioner, India under the ministry of home affairs, government of India. In this present study, Education Development Index constructed by using R software.

II) Principle Component Analysis: - A principle component analysis is concerned with explaining the variance-covariance structure of a set of variables through a few linear combinations of these variables. Its general objective are i) data reduction and ii) interpretations [8].

Principle component analysis can be applied on six literacy parameter and reduces in few principle components summarizing the data without any loss of information. To build the educational development index for each literacy category by using the extracted principle component. The educational development index will be worked out using following formulae [9];

$$Index = \frac{\sum_{i=1}^{6} V_i \sum_{i=1}^{6} F_{ij} E_j}{\sum_{i=1}^{6} F_{ij} E_j}$$

Where
F_{ij} = Factor loading
(variable i, principle components j)
E_j = Eigen value (principle component j)
V_i = Variable i
i, j = 1,2,3,….,6.

III) Composite Variable Rank:-To build up composite variable rank, the state ranks have been worked out for each sub-parameter separately. These ranks for each the sub-parameters then have been combined together to arrive at the composite variable rank [9].

IV) Growth Index:- Growth index attempts to study the growth of the variable over a period of time and is given by the equation [9, 10];

$$Growth\ Index = \frac{\left(\frac{V_{present} - V_{past}}{V_{past}}\right) * 100}{N}$$

Where,
$V_{present}$ = present value
V_{past} = past value
N = No. of year = 10

4. Objectives of Study

This research study has following objectives:

To study the level of educational development index of each state based on Principal component analysis.

To find out the percentage wise ranking of all states of India by using composite variable ranks.

To find out the growth index for the period 2001-2011

To compare the ranks worked out by using principle component analysis, composite variable rank and growth index.

5. Results and discussions

I) Extraction of principal components

Eigen Values for literacy parameter

The Eigen values of principle components analysis is explain the amount of variation extracted by principle component. The six literacy parameter selected such as general male, female (GML & GFL), schedule castes male, female (SCM & SCF) and scheduled tribe male, female literacy (STM & STFL) for studying literacy levels in major states of India.

The ST male and female literacy exhibit a low degree of correlation among all the parameters and other parameters contribute high degree of correlation. The Communalities observed that ST male

Table 1. Eigen value

Principal Component	Eigen Values	Total variance Explained	Cumulative Variance Explained
First	4.06	0.68	0.68
Second	1.8	0.30	0.98

Table 2. Factor loading for literacy variable:

Literacy	Factor Loading	
	First Principal Component	Second Principal Component
GML	**0.97**	0.15
GFL	**0.97**	0.14
SCML	**0.95**	0.26
SCFL	**0.95**	0.24
STML	0.43	**0.90**
STFL	0.41	**0.91**

Table 3. EDI for Literacy parameter

State	Literacy Rate							
	GML	GFL	SCML	SCFL	STML	STFL	Index	Rank
Andhra Pradesh	68.96	55.53	62.20	48.51	50.50	35.04	0.547	19
Assam	65.57	56.18	72.21	61.01	67.65	56.04	0.642	11
Bihar	60.70	44.35	46.01	30.21	49.91	32.79	0.450	24
Chhattisgarh	73.77	57.63	68.85	50.73	58.85	41.38	0.598	17
Goa	83.95	77.96	80.35	69.71	78.11	64.66	0.773	3
Gujarat	76.94	63.93	77.04	61.54	60.16	44.85	0.655	10
Himachal Pradesh	80.98	68.12	75.19	62.69	72.64	56.64	0.708	6
Jammu & Kashmir	66.21	49.41	67.76	52.56	48.21	31.72	0.538	20
Jharkhand	69.30	51.92	54.85	36.00	56.44	38.47	0.523	22
Karnataka	75.56	64.00	64.30	49.34	61.63	46.08	0.615	15
Kerala	85.95	83.91	83.48	77.41	71.29	63.44	0.793	1
Madhya Pradesh	73.43	57.25	64.79	46.24	48.38	33.94	0.554	18
Maharashtra	79.58	69.88	76.35	63.29	63.17	48.69	0.683	7
Manipur	76.33	62.92	72.27	60.20	66.77	59.16	0.676	8
Meghalaya	67.23	58.09	65.01	52.72	60.23	59.23	0.616	14
Mizoram	80.75	70.74	86.62	76.64	78.82	75.85	0.790	2
Odisha	78.41	65.98	68.51	51.12	53.35	34.82	0.602	16
Rajasthan	70.25	48.71	61.37	37.33	55.00	30.52	0.517	23
Sikkim	79.07	68.30	72.58	63.00	75.98	66.38	0.722	5
Tamil Nadu	79.39	68.35	71.81	58.58	53.46	40.88	0.636	12
Tripura	83.72	78.56	81.83	75.89	73.26	60.98	0.771	4
Uttar Pradesh	66.84	50.57	59.78	40.60	54.82	35.80	0.526	21
Uttarakhand	76.19	62.69	71.35	54.46	73.49	56.46	0.671	9
West Bangal	74.69	66.90	68.05	53.91	59.08	41.51	0.621	13

and female literacy have very high variations. From the total variance table, two components of variation have Eigen values greater than one and explain 68% and 30% respectively. From the rotated component matrix, 2 components extracted are

1. General male, female and SC male, female literate are strongly associated with factor 1.
2. ST male, female literates are strongly associated with factor 2.

From principle component analysis, we observed that ST male and female population have low literacy as compare to other in India.

II) Educational Development Index for Literacy Parameters

The Principle Component Analysis (PCA) has reduced six literacy variables into two principle components. The Eigen values of each transformed variables explains the variability in original variables. The formulae applied for estimating index with the help of Principal Component analysis is as follows

$$Index = \frac{\sum_{i=1}^{6} V_i \sum_{i=1}^{6} F_{ij} E_j}{\sum_{i=1}^{6} F_{ij} E_j}$$

Table 3 presents Educational development index for three different categories of all states of India and the state ranks derived by principle component analysis. All states literacy levels have been ranked in the descending order. Kerala has the highest rank for EDI and Bihar is last among all states.

III) Composite Educational Development Index for literacy Parameter

A composite index is a grouping of equities, indexes or other factors combined in a standardized way, providing a useful statistical measure of overall market or sector performance over time, and it is also known simply as a composite [11].

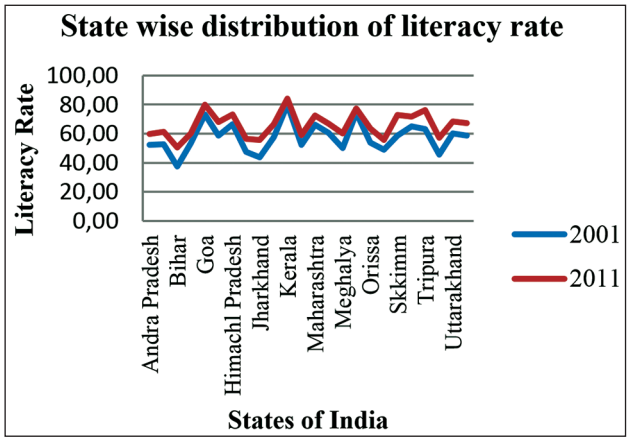
Table 4. Composite index for literacy parameter

Name of State	General		SC		ST		Composite index		
	M	F	M	F	M	F	M	F	Total
Andrapradesh	19	19	20	19	21	19	18	17	18
Assam	23	18	10	9	8	10	19	15	15
Bihar	24	24	24	24	22	22	24	24	24
Chhattisgarh	15	16	13	17	15	15	15	18	16
Goa	2	3	4	4	2	3	2	2	2
Gujarat	10	12	5	8	13	13	10	12	10
Himachal Pradesh	4	8	7	7	6	8	4	5	5
Jammu & Kashmir	22	22	16	15	24	23	22	21	21
Jharkhand	18	20	23	23	16	17	21	22	23
Karnataka	13	11	19	18	11	12	11	13	13
Kerala	1	1	2	1	7	4	1	1	1
Madhya Pradesh	16	17	18	20	23	21	16	19	19
Maharashtra	6	5	6	5	10	11	7	7	7
Manipur	11	13	9	10	9	7	12	10	12
Meghalaya	20	15	17	14	13	6	23	14	17
Mizoram	5	7	1	2	1	1	5	3	3
Orissa	6	10	14	16	20	20	14	16	14
Rajasthan	17	23	21	22	17	24	17	23	22
Sikkim	8	7	8	6	3	2	6	6	6
Tamilnadu	7	6	11	11	19	16	8	8	8
Tripura	3	2	3	3	5	5	3	4	4
Uttar Pradesh	21	21	22	21	18	18	20	20	20
Uttarakhand	12	14	12	12	4	9	9	11	9
West Bangal	14	9	15	13	14	14	13	9	11

In table 4 composite literacy index of all states of India are ranked in descending order.

Table 4 observed that, the composite variable ranking arranges in descending order. The Kerala state leading highest rank in General male, female categories and ST male, female composite variable rank higher in Mizoram state of India.

IV) Growth of Literacy during 2001-2011:-



The above line graph represents the literacy rate of India for the period 2001 and 2011. Bihar state showed low literacy rate in both periods. Kerala state showed highest literacy rate in 2001 and 2011 census survey.

The growth index will provide estimate of the growth in literacy during the period 2001 to 2011. The index has been developed separately for General male, female, Schedule caste male, female, Schedule Tribes male, female literacy population.

There is observing faster growth in literacy for the state Bihar and Jharkhand during period 2001-2011. Bihar got 1st rank for general category but not for Schedule castes and Scheduled Tribes male and female literacy rate. We observe that SC and ST higher growth in literacy for state Mizoram and Goa respectively. In overall discussion Jharkhand state is 2nd rank during this period.

Table 5. State wise Literacy Growth of India

Name of State	General		SC		ST		Total		Total
	M	F	M	F	M	F	M	F	
Andhra Pradesh	18	18	20	19	13	12	22	19	21
Assam	7	6	13	15	21	23	12	12	12
Bihar	1	1	2	2	3	3	1	1	1
Chhattisgarh	6	10	7	11	23	22	10	13	11
Goa	24	24	23	22	1	1	23	23	23
Gujarat	5	7	22	20	17	16	8	14	10
Himachal Pradesh	20	22	21	21	5	9	21	22	22
Jammu & Kashmir	3	5	12	16	7	7	5	4	5
Jharkhand	4	4	5	3	8	6	3	2	2
Karnataka	12	14	8	10	14	15	15	16	16
Kerala	23	23	24	24	9	19	24	24	24
Madhya Pradesh	11	12	16	13	19	13	14	11	13
Maharashtra	19	20	9	12	20	18	20	18	20
Manipur	13	11	4	6	6	14	6	6	6
Meghalaya	9	9	3	4	10	20	2	5	3
Mizoram	10	2	1	1	24	24	17	21	18
Odisha	17	15	17	7	18	5	16	10	14
Rajasthan	9	8	11	8	16	10	9	7	9
Sikkim	22	21	19	23	4	4	7	8	7
Tamil Nadu	15	19	14	17	11	17	19	20	19
Tripura	14	17	15	18	12	11	11	9	8
Uttar Pradesh	2	3	6	5	2	2	4	3	4
Uttarakhand	10	13	10	9	22	21	13	15	15
West Bangal	16	16	18	14	15	8	18	17	17

V) Literacy Index

Table 6. Comparisons of Three Ranking Method

States	Composite Variable Rank	Principal Component Rank	Growth Rank
Andhra Pradesh	18	19	21
Assam	15	11	12
Bihar	24	24	1
Chhattisgarh	16	17	11
Goa	2	3	23
Gujarat	10	10	10
Himachal Pradesh	5	6	22
Jammu & Kashmir	21	20	5
Jharkhand	23	22	2
Karnataka	13	15	16
Kerala	1	1	24
Madhya Pradesh	19	18	13
Maharashtra	7	7	20
Manipur	12	8	6
Meghalaya	17	14	3
Mizoram	3	2	18
Odisha	14	16	14
Rajasthan	22	23	9
Sikkim	6	5	7
Tamil Nadu	8	12	19
Tripura	4	4	8
Uttar Pradesh	20	21	4
Uttarakhand	9	9	15
West Bangal	11	13	17

The above table shows the comparative scenario of Educational development ranks worked out on the basis of three different techniques. All the methods show the Kerala as the leading higher rank in literacy except in growth index. In growth ranking table Bihar state higher rank as compare to the other state. The literacy rate is very low in Bihar then growth at decadal large from the literacy index.

6. Conclusion

The paper presents the empirical analysis of educational development index of all state of India. The deeply discussion concentrate on the result of educational development index on the basis of three techniques like principle component analysis, composite variable index, growth index.

In principle component analysis, create two communalities shows the ST categories secure large variation in literacy rate as compare to other category. Kerala state is leading higher rank in principle component and composite variable rank expecting the growth index. Bihar state leads the highest growth in 2001 to 2011 period. In Bihar state, literacy rate is very low; this state has served social problems that large effect on education schemes.

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Green supplier selection for the need of fruit production using fuzzy logic

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Abstract

The international environment in recent years is process of selecting suppliers in the supply chain set as a key strategic consideration regarding competitive advantage. Changes in environment are constant threat to ecology, causing the needs for selecting green agricultural machinery which will be in accordance with the requirements of organic production. The choice of green suppliers of agricultural machinery is one of the most important links in the process of ecological fruit production, and very important from the economic standpoint, because financial allocations for machinery are greatest in the whole chain of integrated agricultural production. This paper examines the choice of green suppliers using Fuzzy multi-criteria approach. Experts will use the value of linguistic criteria and evaluate the alternatives. Linguistic alternatives will be transformed by Fuzzy logic, and using methods of fuzzy AHP, fuzzy TOPSIS and fuzzy Entropy will form ranking for suppliers. The results will help farms to establish a systematic approach to solve choice of green suppliers and application of this model to solve problems in real life**.**

Key words: green supplier selection, financial aspect, fruit production, fuzzy AHP, fuzzy TOPSIS.

1. Introduction

Today's international environment has forced many organizations to focus on quality in supply management while gaining market from others. Green supplier selection is process with which question of environment protection and problems with supply management is formally introduced and integrated.

Purchasing is a primary function for any organization, so selecting the best supplier is a vital component of the business relationship and it is one of the most critical issues in the competitive environment [1]. This means that organizations must cooperate with suppliers on eco-friendly purchasing practices and materials management.

Selection of green supplier for Agricultural mechanization is one of the main pieces needed in process of ecological fruit production, and that is also important from economical standing, as the financial allocation for mechanization is greatest in the whole chain of integrated agricultural production.

Integrated production is economical production of high quality fruit that gives priority to environment-friendly production methods, in order to minimize adverse impacts and increase environmental protection as well as human health, with supports of multiple functions in agriculture, which is the reason for emphasized importance of green suppliers.

According to the aeromechanical measures of this concept for fruit growing involves intensified fruit production, provided that the application of chemicals are not carried out continuously, but preventively. It is of great importance to agricultural machinery conforms for the requirements of this production. In practice, it often happens that even if you select and apply products from "green list", its application is called into matter by mishandling, and this is often due to the application of obsolete technology and machinery that does not meet environmental standards. GSCM practices would naturally insist upon environmental regulations being followed in order to abide by Restriction on Hazardous Substances (RoHS) directives, and to evaluate supplier compliance to hazardous substance management. [2]

This paper examines the choice of green suppliers using fuzzy multi-criteria approach. The experts will evaluate the value by linguistic criteria and alternatives, so the process of decision-mak-

ing gets closer to the subjective human perception. These linguistic values will use fuzzy logic to generate a result of the overall performance score for each supplier. Featured Numerical example will demonstrate the effectiveness of the proposed approach where subjective and objective factors determine weight criteria that will influence the selection of green supplier. Fuzzy AHP method will determine the subjective weight for main criteria and Fuzzy entropy method will determine objective weight sub-criteria. Fuzzy TOPSIS method in combination with the results of the previous two methods result will give the formation of the ranking of alternatives for each of the experts.

2. Green supplier selection criteria

Traditionally, companies consider criteria such as price, quality and lead time, when evaluating supplier performance and do not give enough attention to environmental criteria as a mean to evaluate suppliers. Now, many companies have begun to implement green supply chain management (GSCM) and to consider environmental issues and the measurement of their suppliers' environmental performance. [3][4] Due to the characteristics for selection of the green selection, criteria that were selected are shown in picture 1.

3. Methodology

This paper uses several fuzzy methods including Fuzzy TOPSIS (fuzzy technique for order preference by similarity to an ideal solution), Fuzzy AHP (fuzzy analytic hierarchy process) and Fuzzy entropy. The combination of these fuzzy methods, which will be presented below, is used in the methodology of selection of green suppliers of agricultural machinery with integrated fruit production.

3.1 Fuzzy AHP

Fuzzy AHP, and a fuzzy extension of AHP are used to solve the hierarchical rating of fuzzy

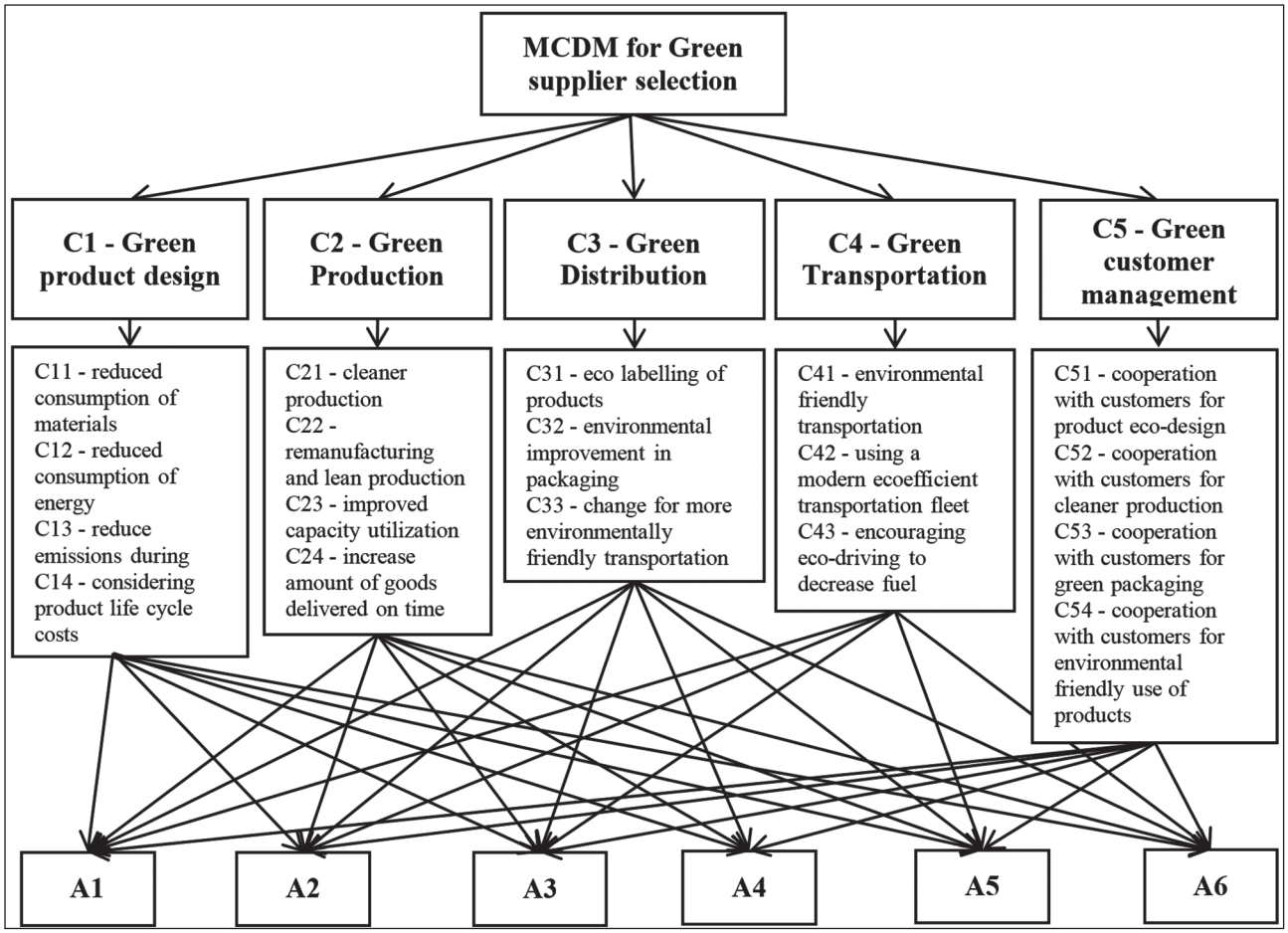

Figure 1. Green supplier selection criteria

MCDM problems. AHP itself involves the principles of decomposition, pairwise comparisons, and priority vector generation and synthesis. [5]

The Structure of this method is illustrated as follows:

Step 1. To construct the pair wise comparison matrix by using triangular fuzzy number (TFN) [6]

$$\tilde{F} = \begin{bmatrix} 1 & \bar{f}_{12} & \cdots & \bar{f}_{1n} \\ \bar{f}_{21} & 1 & \cdots & \bar{f}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \bar{f}_{n1} & \bar{f}_{n2} & \cdots & 1 \end{bmatrix}, \bar{f}_{ij} = 1/\bar{f}_{ji};\ \forall i, j \ldots (1)$$

Where $\bar{f}_{ij}$ indicates the relative importance of each pair of elements in the same hierarchy.

Step 2. Fuzzy priorities are derived from comparison matrix Ã. This is done using the eigenvalue method or any other method used in traditional AHP [7]

Step 3. As these fuzzy priorities must be ranked, they need to be translated into real numbers to make the ranking more obvious than fuzzy numbers. Several methods exist including the weighted average approach, the center of area, the mean max membership and the first (or last) of maxima. The most popular is the center of area or centroid [8].

3.2 Fuzzy TOPSIS

TOPSIS, one of the classical methods for solving MCDM problems, was originally proposed by Hwang and Yoon [9]. The concept of TOPSIS is based on the theory that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) for solving a MCDM problem. [10]

The TOPSIS solution method consists of the following steps: [9] [11]

Step 1. Construct the decision matrix. This matrix shows assessments of alternatives according to criteria.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix} \end{array} \quad \ldots\ldots\ldots\ldots (2)$$

where A_i denotes the alternative i, (i = 1, 2, … , m); C_j represents *j*th criterion, (j = 1, 2, … , n), and f_{ij} is a crisp value showing the performance rating of each alternative A_i with respect to each criterion C_j.

Step 2. Normalize the decision matrix (R). The normalized value r_{ij} is calculated as:

$$R = [r_{ij}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, for fuzzy data denoted by triangular fuzzy number as (a_{ij}, b_{ij}, c_{ij}), the normalized values for benefit-related criteria and cost-related criteria are calculated as follows [12]:

$$\begin{aligned} r_{ij} &= \left(\frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j} \right), j \in B \\ c_j &= \max_i c_{ij}, j \in B \\ r_{ij} &= \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right), j \in B \\ a_j^- &= \min_i a_{ij}, j \in C \end{aligned} \quad \ldots\ldots\ldots\ldots (4)$$

Step 3. Weighted normalized decision matrix v_{ij} is calculated by multiplying normalized matrix with the weights of the criteria [12]:

$$V = \left[v_{ij} \right] mn,\ i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n \quad \ldots\ldots (5)$$

Where $v_{ij} = r_{ij} \cdot w_j$ and w_j is the weight of the *j*th attribute or criterion.

Step 4. The fuzzy positive-ideal solution (FPIS, A^*) and fuzzy negative-ideal solution (FNIS, A^-) can be calculated as:

$$A^* = \left(v_1^*, v_2^*, ..., v_n^*\right)$$
$$A^- = \left(v_1^-, v_2^-, ..., v_n^-\right)$$
$$where\ v_i^* = \max_i \left\{v_{iia}\right\}\ and \quad \text{..... (6)}$$
$$v_i^- = \min_i \left\{v_{iia}\right\}, i = 1, 2, ..., m$$

Step 5. Calculate the distances of each initial alternative to PIS and NIS. The distance of each alternative from fuzzy positive ideal reference point and fuzzy negative ideal reference point can be derived respectively as:

$$d_i^+ = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^+\right), i = 1, 2, ..., m;$$
$$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), i = 1, 2, ..., m; \quad \text{..... (7)}$$

where $d\left(\tilde{v}_{ij}, v_j^+\right)$ denotes the distance between two fuzzy numbers and calculated d_i^* represents the distance of alternative A_i from PIS and d_i^- i is the distance of alternative Ai from NIS.

Step 6. The closeness coefficient (CCi) of each alternative is calculated as:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*}, i = 1, 2, ..., m \quad \text{..... (8)}$$

At the end of the analysis, the ranking of alternatives is determined by comparing CCi values. Alternative A_i is closer to the FPIS (A^*) and farther from FNIS (A^-) as CC_1 approaches to 1. The ranking order of all alternatives is determined according to the descending order of CC_1.

3.3 Fuzzy entropy

The index weight is determined based on the entropy theory after membership data of the first class index are obtained through the fuzzy evaluation. [13] The procedure is as follows:

In order to determine objective weights by the entropy measure, the decision matrix needs to be normalized for each criterion. [14] After normalized the decision matrix, we can calculate the entropy values e_j as:

$$e_j = -k \sum_{j=1}^{n} p_{ij} ln\, p_{ij} \quad \text{..... (9)}$$

k is a constant, let $k = \left(\ln(m)\right)^{-1}$ The degree of divergence d_i of the intrinsic information of each criterion C_j (j = 1, 2,. . ., n) may be calculated as:

$$d_j = 1 - e_j \quad \text{..... (10)}$$

The value d_j represents the inherent contrast intensity of c_j. The higher the d_j is, the more important the criterion cj is for the problem. The objective weight for each criterion can be obtained.

$$w_j = \frac{div_j}{\sum_j div_j} \quad \text{.....(11)}$$

4. Results of fuzzy multi criteria approach for green supplier selection

In the example for selection of green supplier when purchasing agricultural machinery that are needed for integrated production, there were contacted three experts who completed the questionnaire for each of the 6 used suppliers. The questionnaire consists of two parts. In the first section designated for a subjective determination of weight criteria where was used 10 questions paired to compare main criteria. In the second part of the questionnaire provided for the assessment of suppliers there were 18 questions where the experts evaluated each supplier with linguistic values.

When using the first part of the questions the experts had to compare the main criteria and then allocate some of the values presented in Table 1. Results of their questionnaire are presented in Table 2. Based on the result given by Fuzzy AHP method we see expert 1 gives most weight on the Green product design criteria, while experts 2 and 3 give more weight to the Green Production criteria.

Second part of questionnaire that consisted of 6 parts where each supplier was individually rated by experts on the scale of 7 linguistic values for their performance based on established sub-criteria presented on the Picture 1. Used linguistic values are presented in the table 3 along with corresponding Fuzzy numbers.

Table 1. Fuzzy linguistic rating of criteria (Taylan, et.al 2014)

Definition	Numerical rate	Description
Equally importance	(0,1,1)	Two criteria equally contribute
Weak importance of one over another	(1,3,5)	Experience and judgment slightly favor one criterion over another
Strong importance	(3,5,7)	Experience and judgment strongly favor one criterion over another
Very strong importance	(5,7,9)	A criterion is favored very strongly, its dominance demonstrated in practice
Absolute importance	(9,9,10)	The evidence favoring one criterion over another is of the highest possible order of affirmation

Table 2. Results of fuzzy AHP method

DM1						
	C1	C2	C3	C4	C5	w
C1	(1,1,1)	(1,3,5)	(3,5,7)	(3,5,7)	(1,2,4)	0,41
C2	(1/5,1/3, 1)	(1,1,1)	(1,3,5)	(1,3,5)	(1,2,4)	0,22
C3	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1,1/2,1/4)	(1,3,5)	0,12
C4	(1/7,1/5,1/3)	(1/5,1/3,1)	(4,2,1)	(1,1,1)	(1,3,5)	0,14
C5	(1/4,1/2,1)	(1/4,1/2,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,1,1)	0,10
DM2						
	C1	C2	C3	C4	C5	w
C1	(1,1,1)	(1,1/2,1/4)	(2,4,6)	(1,2,4)	(1,2,4)	0,25
C2	(4,2,1)	(1,1,1)	(3,5,7)	(1,3,5)	(1,3,5)	0,36
C3	(1/6,1/4,1/2)	(1/7,1/5,1/3)	(1,1,1)	(1,1/2,1/4)	(1,1/3,1/5)	0,12
C4	(1/4,1/2,1)	(1/5,1/3,1)	(4,2,1)	(1,1,1)	(1,1/2,1/4)	0,17
C5	(1/4,1/2,1)	(1/5,1/3,1)	(5,3,1)	(4,2,1)	(1,1,1)	0,11
DM3						
	C1	C2	C3	C4	C5	w
C1	(1,1,1)	(1,1/2,1/4)	(1,1,1)	(1,3,5)	(1,1/2,1/4)	0,16
C2	(4,2,1)	(1,1,1)	(1,2,4)	(3,5,7)	(1,2,4)	0,35
C3	(1,1,1)	(1/4,1/2,1)	(1,1,1)	(1,3,5)	(1,1/2,1/4)	0,16
C4	(1/5,1/3,1)	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1/2,1/4,1/6)	0,07
C5	(4,2,1)	(1/4,1/2,1)	(4,2,1)	(6,4,2)	(1,1,1)	0,26

Given results based on the second part of questionnaire are presented in the table 4

Table 3. Linguistic variable for the rating

Linguistic variable	Fuzzy numbers
Very poor (VP)	(0,0,1)
Poor (P)	(0,1,3)
Medium poor (MP)	(1,3,5)
Medium (M)	(3,5,7)
Medium good (MG)	(5,7,9)
Good (G)	(7,9,10)
Very good (VG)	(9,10,10)

Using the membership function of fuzzy numbers presented in the Table 4 results are transformed from linguistic values to fuzzy numbers. After the transformation normalization is applied to these fuzzy numbers using the expression (4). Following normalization of the data, weight for sub-criteria is calculated based on the fuzzy entropy and those results are presented in the Table 5. These weights are used to effect the calculation of the criterion value for each supplier using Fuzzy TOPSIS method. Given results for fuzzy TOPSIS method for each of the criteria and for each of the experts is presented in table 6.

Table 4. Linguistic values of the decision makers

.	DM1						DM2						DM3					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
C11	M	MP	MG	M	MP	MG	MP	G	MG	M	G	M	MP	MG	MG	M	M	MP
C12	MG	M	MP	MP	MG	M	M	MG	M	MG	G	M	MG	MG	M	MG	M	MP
C13	M	MP	M	MP	M	MP	MP	M	M	MG	MG	M	M	M	MG	M	MG	M
C14	MG	M	MP	M	MG	MG	MP	M	MP	M	M	MP	MG	MG	M	M	M	MP
C21	M	MP	MG	MG	M	M	M	M	MG	M	MG	M	MG	G	MG	M	MG	MG
C22	M	MG	MP	M	MG	MP	MG	G	MG	MG	G	M	M	MG	M	MG	G	MP
C23	MG	MP	MP	MP	M	MG	M	MG	MG	M	M	MP	MP	MG	M	MG	M	M
C24	M	MP	M	MP	M	MP	MG	M	G	MG	G	MG	M	MP	M	M	MG	MP
C31	VG	VG	G	MG	G	G	M	MG	M	M	MG	G	MG	MG	M	M	MP	MG
C32	MP	M	MG	G	MP	M	MP	G	M	MG	MG	M	MP	MG	MG	MG	M	M
C33	MP	MP	M	M	MG	M	MP	M	MG	M	MG	MG	M	M	MP	MP	MG	MP
C41	M	MG	MP	MP	M	MP	MG	MG	M	MG	G	M	M	G	G	MG	MG	MG
C42	M	M	MP	MG	M	MG	M	M	MP	MP	MG	M	G	VG	G	M	G	MG
C43	M	MP	MG	M	MP	M	MP	MG	M	MG	M	MG	MG	M	MP	MG	M	M
C51	G	MG	G	MG	MG	G	MG	M	MG	M	MG	M	M	MG	MG	M	M	MP
C52	G	MP	M	M	MG	M	M	MG	M	MG	G	MG	M	G	MG	M	MG	M
C53	G	G	MG	MG	M	G	MP	MG	M	M	MG	M	MG	M	M	MG	M	MG
C54	VG	G	G	MG	G	MG	M	M	MG	G	MG	M	M	MG	MG	MG	M	MP

Table 5. Results of weight sub-criteria used fuzzy entropy

	DM1 w	DM2 w	DM3 w
C11	(0,22;0,24;0,25)	(0,21;0,23;0,24)	(0,20;0,24;0,24)
C12	(0,22;0,24;0,25)	(0,28;0,26;0,25)	(0,25;0,25;0,25)
C13	(0,27;0,26;0,26)	(0,25;0,25;0,25)	(0,30;0,26;0,26)
C14	(0,28;0,25;0,25)	(0,25;0,26;0,25)	(0,25;0,25;0,25)
C21	(0,29;0,26;0,25)	(0,26;0,26;0,25)	(0,31;0,27;0,26)
C22	(0,23;0,25;0,25)	(0,26;0,25;0,25)	(0,23;0,24;0,25)
C23	(0,22;0,23;0,24)	(0,22;0,24;0,24)	(0,25;0,25;0,25)
C24	(0,26;0,26;0,26)	(0,26;0,25;0,25)	(0,22;0,25;0,25)
C31	(0,39;0,35;0,34)	(0,35;0,34;0,34)	(0,35;0,34;0,33)
C32	(0,28;0,32;0,33)	(0,32;0,33;0,33)	(0,35;0,34;0,33)
C33	(0,32;0,33;0,33)	(0,33;0,33;0,33)	(0,29;0,33;0,33)
C41	(0,30;0,33;0,33)	(0,36;0,34;0,34)	(0,35;0,34;0,34)
C42	(0,36;0,34;0,34)	(0,31;0,33;0,33)	(0,34;0,33;0,33)
C43	(0,34;0,33;0,33)	(0,33;0,33;0,33)	(0,31;0,33;0,33)
C51	(0,29;0,26;0,25)	(0,28;0,26;0,25)	(0,23;0,25;0,25)
C52	(0,20;0,23;0,24)	(0,27;0,25;0,25)	(0,26;0,25;0,25)
C53	(0,23;0,25;0,25)	(0,20;0,24;0,24)	(0,28;0,26;0,25)
C54	(0,28;0,26;0,25)	(0,26;0,25;0,25)	(0,23;0,24;0,25)

Based on result of the criteria and weights given by Fuzzy AHP method is calculated final value for each supplier.

Final results show that best result has been accomplished by Supplier A1 with experts 1 and 2, contrary to beliefs of expert 2 whose results say that supplier A5 has the best performance. With more detailed analysis can be seen that the expert 2 has small differences between the top three places. Based on the opinions of the experts and conducted research, a decision is made that the supplier A1 has the best performance when it comes to choosing green supplier in the procurement of agricultural machinery in Integrated Fruit Production.

Table 6. Final results

	DM1					
w	C1 0,41	C2 0,22	C3 0,12	C4 0,14	C5 0,10	Results
A1	0,7992	0,3810	0,2069	0,5000	1,0000	0,6063
A2	0,3877	0,6197	0,3758	0,5000	0,3972	0,4501
A3	0,5378	0,5451	0,6566	0,4142	0,4629	0,5235
A4	0,2831	0,4963	0,6737	0,5000	0,3578	0,4119
A5	0,6582	0,5998	0,5560	0,3660	0,4830	0,5681
A6	0,6414	0,5406	0,5287	0,5000	0,5066	0,5660
	DM2					
w	C1 0,24	C2 0,37	C3 0,12	C4 0,16	C5 0,12	Results
A1	0,7992	0,3810	0,2069	0,5000	1,0000	0,5568
A2	0,3877	0,6197	0,3758	0,5000	0,3972	0,4938
A3	0,5378	0,5451	0,6566	0,4142	0,4629	0,5308
A4	0,2831	0,4963	0,6737	0,5000	0,3578	0,4546
A5	0,6582	0,5998	0,5560	0,3660	0,4830	0,5625
A6	0,6414	0,5406	0,5287	0,5000	0,5066	0,5591
	DM3					
w	C1 0,16	C2 0,35	C3 0,16	C4 0,09	C5 0,25	Results
A1	0,7992	0,3810	0,2069	0,5000	1,0000	0,5893
A2	0,3877	0,6197	0,3758	0,5000	0,3972	0,4773
A3	0,5378	0,5451	0,6566	0,4142	0,4629	0,5312
A4	0,2831	0,4963	0,6737	0,5000	0,3578	0,4548
A5	0,6582	0,5998	0,5560	0,3660	0,4830	0,5554
A6	0,6414	0,5406	0,5287	0,5000	0,5066	0,5431

5. Conclusion

In accordance with EU directives on the necessity of introducing green practices in business organizations, there is an increasing pressure on management to align their production standards (EUGAP-) good agricultural practices and protection of the environment. In the agricultural production, there has been imposed the concept of integrated production which by peculiarities, gives priority to environmentally-friendly methods of production that minimize adverse impacts on the environment. In the terms of economy it gives better results due to its production volume of organic production.

In the business of any organization that wants to be part of good environmental practice green choice of suppliers is one of the first links in that chain. By choosing green suppliers organizations in accordance with international regulations "good agricultural practices" GAP "can help to reduce the environmental and legal risks and increase the competitiveness of the company.

In this paper, we showed a fuzzy multi-criteria approach with choice of green suppliers using the opinions of experts. The experts through linguistic values have evaluated the criteria and alternatives. With Fuzzy AHP method is gained the weight of main criteria and with Fuzzy entropy method was determined the weight of the sub-criteria. Fuzzy TOPSIS method calculates the value criteria using the weight obtained by the fuzzy entropy method and using the weight obtained by fuzzy AHP method forms ranking list of alternatives and selects supplier A1. Two experts choose same supplier as best and that was supplier A1. The third expert had a different choice, according to this expert the best results has achieved supplier A5.

The reason for this must be found in the fact that the results given by fuzzy AHP method have different weight for main criteria. Weight results for sub-criteria that were obtained by fuzzy entropy showed that there is no significant discrepancies between them.

Having in mind that this research is based on the expert opinions, the instructions for future researchers is to examine certain agricultural branches and sectors with a larger number of subjects in the field to ensure the validity of the research. Furthermore, the question of the risks associated with green choice of supplier can be displayed in future research. Selection of supply chains are aimed at ensuring that their suppliers act in a socially responsible manner with respect to GAP practices and environmental protection.

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The role of headmaster to improve pedagogic competence of teachers in Vocational high school

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Abstract

Teachers should not only be competent academically, but they should also possess pedagogical competence to be able to understand their students. However, each teacher needs guidance from the principals at each school. This study aims to determine the role of the principal in improving the pedagogical competence of teachers in vocational high schools. This study was conducted by conducting interviews and providing questionnaires to teachers in vocational high schools in Padang-Indonesia. The results of this study indicate that a principal should be able to be educator, manager, administrator, supervisor, leader, innovator, and motivator for teachers at school. Although the role of principals is simple, it is very much needed by teachers. The principal's role significantly influences the teacher's pedagogical competence. In the future, a principal should be able to master every problem that exists in vocational high school.

Key words: the role of principals, pedagogical competence, competence of teachers, secondary vocational schools, professional principals.

1. Introduction

Government of Indonesia bill Number 20 of 2003 on National Education System stipulates that national education aims to develop the potential of students to become believers and to be devoted to the One True God, to be noble, healthy, knowledgeable, capable, creative, democratic and responsible citizens. In order to realize the government's expectations and to keep the community informed about it, it is imperative that qualified teachers be teachers with good competence so that they can carry out their duties and responsibilities in order to invigorate the nation of Indonesia [1].

One of the key aspects of the effort to improve the quality of education is to improve the quality of teachers by improving the competence of teachers maximally according to the conditions of teacher competency qualification towards professional teachers. This is because teachers play a very important role in the smooth running of the education process in the classroom, as well as determining the level of achievement of the learning process. Therefore, the construction of teacher quality and teacher competence should be done well [1], because teachers are the most important determinants in achieving educational excellence. Although there is a good curriculum and complete facilities, if no skilled teachers, educational excellence is difficult to achieve [2]. Teachers have an important role in designing the learning environment in the classroom [3].

The Sanusi study [4] shows that teachers' pedagogical competence is still categorized as low because teachers do not have the expertise in mastering the learning method. The low teachers' pedagogical competence could be seen from the process of teaching and learning, which is ineffective, inefficient and of low quality [5]. The role of school principals can be seen in Figure 1 below.

In addition to the competence of teachers, quality of education is strongly influenced by the leadership role of the school principal [6,7,8]. Therefore, to achieve quality education, a school principal must be competent to carry out its role in school. Therefore, all activities in the school are the responsibility of the principal. In addition, principals have the primary task of giving guidance and motivation to teachers and staff in implementing teaching and learning in schools, as well as giving teachers the freedom to use school facilities [9].

Role of principals is often expressed as educators for teachers and school staff in order to create a harmonious atmosphere and to improve teachers' competency [10,11]. Managing one of the most important things in an organization, in this case the school, the school organization manages the process of organization, organization, direc-

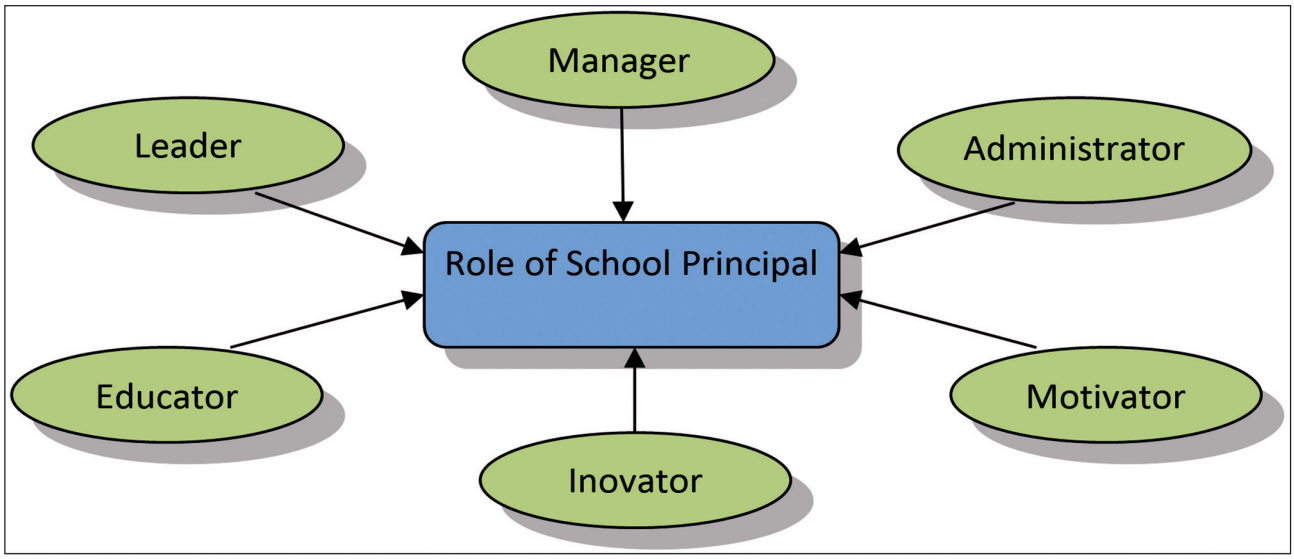

Figure 1. Role Model School Principal

tion and control of all members of the organization and strengthens the organization's resources to achieve the organization's intended purpose. In addition, school leaders must have expertise in school management to coordinate the implementation of educational administration programs, administrative procedures and records, staff administration, financial administration and administrative and administrative facilities of students. These activities need to be done in an efficient and effective way to support school productivity [12].

School principals must work with teachers as supervisors in developing programs to be implemented. As school supervisors, principals are responsible for carrying out supervisory activities on the implementation of the learning process and the way in which teachers implement the curriculum to develop the quality of education in schools [13,14]. In addition, principals must monitor the activities carried out by school leaders to protect the implementation of principles designed together through collaborative relationships [15].

Behbahani [16] states that principals in leadership must apply leadership styles to suit the circumstances and needs. This is particularly important in promoting creativity in enhancing teacher competence. The role of school principals as the leader is the ability to achieve the goals based on the vision of school missions by leveraging the public in the school environment.

Hallinger *et al.* [17] explain that the ability to achieve success in school includes the role of school principals to provide new ideas and support teachers to have high knowledge, skills and motivation. Crow and Peterson [18] revealed that the school principal as an innovator has the ability to develop goals to promote and mobilize the entire staff in the organization he leads to perform the best work. School principals should have new creativity and thought to facilitate translating school vision and mission, and school principals must have the ability to carry out investigations in their role [19].

As motivator, school principals should have the right strategic principles and be able to provide advice to ensure maximum work output of subordinates [20]. This motivation can be done well when the work environment / school is good, a pleasant work environment and discipline culture is well maintained, using reward as motivation for educational personnel [14].

The pedagogical competence is the ability of teachers to understand the characteristics of students in terms of emotional, moral, and intellectual aspects. It requires a teacher to have the ability to master the learning theory and the principles of learning, because students have different characters, traits, and interests. This ability enables teachers to understand the willingness and readiness of their students in a process of teaching and learning.

2. Methodology

Implementation of research is conducted by an unequal combination method or Concurrent

Embedded Mixed Method Design [21,22]. This study was conducted at 10 State Vocational High Schools in Padang City. The teacher population in Padang City, according to Padang City Diknas, is 865 people spread over 10 vocational high schools in Padang City.

The use of interview as a data gathering instrument was conducted on selected teachers and school principals through sampling methods aimed at interview. The main purpose of the interview is to obtain information about the role of school principals in improving teacher competence.

In this study, two types of questionnaires were used, namely the questionnaire on the role of school principals and questionnaires on teacher competence. The questionnaire consisted of questionnaires about the role of school principals in improving teacher competence, and questionnaire about teacher's own competence. The questionnaire consists of three parts, and included the background of the respondent, the role of the school principal, and the teacher's competence.

This study uses an unstructured interview. The selection of this type of interview is intended to enable the researcher to ask questions unambiguously and to ask opinions or ideas about the issues being interviewed, making it possible to obtain more open information. In order to do so, an interviewer should provide tools such as compact discs or records so that all information presented by the information can be recorded.

Quantitative analysis is the process of displaying data and interpreting quantitative data [23]. Quantitative analysis is also used to make the generalization of the sample into the population, meaning the phenomenon or occurrence of the study sample obtained from the analysis results can be generalized to the population. Furthermore, Tiro [24] argues that in order to obtain the answers to the questionnaire, the data analysis method must be in line with the study pattern and the variables studied. In this study, there are two types of data, namely quantitative data obtained through the questionnaire and the types of qualitative data obtained from interviews with respondents. The survey data analysis methods used a combination of methods *(mixed methods)*.

In line with the research, there are two types of data analysis, namely quantitative and qualitative data analysis. Especially for quantitative data analysis, survey group B and C, researchers are using the application program *SosialScience Statistical Package for* Social Sciences (SPSS) for Windows 21.0. In this case, the analysis of the research data was done by using descriptive analysis and increment analysis at the significance level of 0.05 (a <0.05). Explanation of the use of both types of statistical analysis is shown in the following descriptions.

3. Results and discussion

a) The principal role of the teacher

Based on Table 4.6, it is shown that the role of principals as educators is moderate because their mean value is 3.65 with standard deviation .783, which means that the role of the principal as educator needs to be increased to increase the competency of state vocational high school teachers in Padang City. The numbers expressed as frequencies and percentages also indicates the role of principals as educators is always moderate but medium-level categories are high because the dimensions are almost gradually high, where the number of 4 points is more than half, recording 138 and 52.9 percent. It is also found that the role of a principal as a manager is simple because the mean value is only 3.45 with the standard deviation of .749. Most of the frequencies are in the 4 point scale of 115, or 44.1 percent. It is of the utmost importance that principals' ability to improve their role in improving teacher competence continues to be enhanced.

Table 1 shows that the role of principals as an administrator should be enhanced as descriptively it is found that the role of principals is still moderate in relation to improving teacher competence. This is due to the mean value of the moderate graduated teachers of 3.41 with the standard deviation of 0.758. The number of frequencies is mostly in the 3 point scale of 112 or 42.9 percent and 4 point scale, which is 104 or 39.9 percent. Because the majority are on the 3-point scale, the stage is simple. The same thing happens to the role of the principal as a moderate supervisor because the mean value is only 3.51 with the standard deviation of 0.719. The number of frequencies shows the same as the majority of the respondents' perceptions on the role of the principal on a 4-point scale of 114 or 43.7 per

Table 1. Descriptive Analysis Based on the findings of Phase Role of Principals

Variable	SKALA					Number of items	Min	Standard deviation	Stage
	STS No (%)	TS No (%)	TP No (%)	S No (%)	SS No (%)				
For Educators	3 (0.2)	19 (7.3)	63 (24.1)	138 (52.9)	38 (14.6)	6	3.65	0 .783	Simple
As Manager	5 (1.9)	25 (9.6)	95 (36.4)	115 (44.1)	11 (4.2)	5	3.45	.749 0	Simple
As Administrator	5 (1.9)	24 (9.2)	112 (42.9)	104 (39.9)	16 (6.1)	5	3.41	0 .758	Simple
As Supervisor	3 (1.1)	20 (7.7)	100 (38.3)	114 (43.7)	24 (9.2)	5	3.51	0 .719	Simple
As leader	5 (1.9)	19 (7.3)	114 (43.7)	102 (39.1)	15 (5.7)	6	3.37	0 .775	Simple
As an Innovator	2 (0.8)	15 (5.7)	86 (33.0)	125 (47.9)	33 (12.6)	4	3.55	0 .742	Simple
As motivator	1 (0.4)	20 (7.7)	91 (34.9)	134 (51.3)	15 (5.7)	5	3.53	0 .650	Simple
Min Overall Role of Principal						**36**	**3.50**	**0 .659**	**Simple**

Table 2. Descriptive Analysis Based on the findings of Teacher Competency Level

Variable	SKALA					Number of items	Min	Standard deviation	Stage
	STS No (%)	TS No (%)	TP No (%)	S No (%)	SS No (%)				
Pedagogical aspects	2 (0.8)	18 (6.9)	90 (34.5)	139 (53.3)	12 (4.6)	9	3.50	0 .646	Simple
Personality Aspects	-	24 (9.2)	92 (35.3)	124 (47.5)	24 (9.2)	6	3.49	0 .755	Simple
Professional aspect	-	6 (2.3)	98 (37.6)	140 (53.6)	17 (6.5)	7	3.64	0 .579	Simple
Social aspects	-	13 (5.1)	61 (23.4)	110 (42.2)	77 (29.5)	6	3.83	0 .759	Height
Overall Mean Teacher Competence						**28**	**3.62**	**0 .485**	**Simple**

cent and a 3-point scale of 100 or 38.3 per cent. The role of principals as a leader is also simple, because the mean value is 3.37 with the standard deviation of 0.775. The number of frequencies and percentages can be supported as the majority are on a 3-point scale with a frequency of 114 or 43.7 per cent and a 4-point scale of 102 or 39.1 per cent. It means that the role of principals as leaders has not been felt by teachers in improving their compatibility.

It is also found that the role of the principal as an innovator and motivator is also at moderate level as the mean value of the role of the principal as an innovator is 3.55 with the standard deviation of 0.742 and as the motivator has a mean value of 3.53 with the standard deviation of 0.650. This finding also means that the role of principals in improving teacher competence on the side of innovation and motivation is still needed to be improved. Both principals' roles have the majority of perceptions on the 4-point scale but many teachers also give perceptions at the 3-point scale.

b) Vocational High School teacher competency

Based on Table 4.7 it is found that overall the level of teacher competence is moderate because the mean value is 3.62 with the standard deviation of 0.485. This finding means that teachers' overall competence in Padang City is still moderate and should be noted by principals and stakeholders such as government leaders.

While being observed alone, it is found that there is only one dimension of teacher competence that has a high degree of social competence as the mean value is 3.83 with a standard deviation of 0.759. According to the number of frequencies, one teacher's competence was found at a 4-point scale of 110 (42.2 percent) and a 5-point scale of 77 (29.5 percent). This finding also implies that the competence of state vocational high school teachers in Padang City has a social life because of the high level of feedback by teachers.

It is also found that teachers' competence as pedagogy is moderate because their mean value is 3.50 with standard deviation 0.646. It was found that the majority of the frequency was on a 4-point scale of 139 or 53.3 per cent. This means that the teachers have a high degree of competence on the pedagogical side. This is interesting because they should have pedagogical skills in carrying out their duties as educators for their students, but this is not the reality. Therefore the teacher's competence on this side is very important.

c) Role of Principals on Teacher Competence

The findings of multiple linear regression analysis as in Table 3 show that overall the role of principals on teachers' competence is significant because the significant value of F (12.984) is 0.000. The significant decision of the principal role of teacher competence was significant and the fifth hypothesis of the study was unacceptable or rejected because sig value was 0.000 less than the value of alpha 0.05.

In Table 3, this study also found that the influence of principals' role dimensions was 28.7 percent. It means that overall principals' influence is only 28.7 percent or there are other factors that influence teacher competence but are not included in this study. This is supported by a high or constant value of 3.338 and a significant value of 0.000. It can be seen that there are three dimensions or indicators of role of principals that do not significantly affect teachers' competence i.e. the role of principals as managers because their significant value is greater than alpha (0.933> 0.05). This finding implies that the role of the principal as a manager needs to be improved to ensure the competence of teachers in carrying out their duties.

Second is the role of the principal as an administrator with a significant value greater than the alpha value of 0.775, which is greater than 0.05. This finding gives the sense that the principals as administrators really need to pay attention to the competence of teachers so that could affect the success of the assignment of the state vocational secondary school teachers in the city of Padang. Finally, it is found that an indicator that does not significantly affect the competence of the teacher is the role of the principal as a leader because the significant value is higher than the alpha value (0.491> 0.05). It is therefore imperative for all principals to be able to play their role as a leader in the success of teacher competence.

Further findings shown in Table 3 are indicators or dimensions of the role of the state vocational

Table 3. The results of regression analysis constructs of the influence of the role of Principal in Teachers Competency

Role of Principal / Independent Variables	Î²	*T*	Sig
Constant / Constant	3.338	20.871	0 000
As an Educator	0.148	2.406	0.017
As a Manager	-.009	-0.085	0.933
As Administrator	0.033	0.287	0.775
As Supervisor	0.244	4.056	0.000
As a Leader	-0.225	-0.716	0.491
As an Innovator	0.297	3.103	0.002
As Motivator	0.219	2.330	0.021
The dependent variable: Teacher Competence adjR ^{2} = .287 R = .514 F = 12.984 R ^{2} = .309 sig = .000			

high school principals in the city of Padang, which significantly affect the competence of teachers. Comparative indicators are the role of principals as educators, the role of principals as supervisors, the role of principals as innovators and the role of principals as motivators.

d) Teacher competence based on interview results

This qualitative section is used to support the quantitative analysis of answers in the first study question. To illustrate the findings of the qualitative study according to the level of competence of the teacher, the first researcher shows that as many percent of respondents give an impression frequency on this question.

Based on Table 4, the frequency of respondents who responded to the socio-competence level of the teachers had the highest number of respondents interviewed i.e. five or 83 percent of respondents, with only one or 17 percent of respondents who stated moderate. Interviewees were interviewed about the involvement of teachers in social activities that could contribute to increasing the competence of teachers as educators. While the frequency and percentage of respondents' perceptions were the lowest in the pedagogical competence of teachers, it was found that only four or 67 percent of respondents gave a moderate statement and there were two or 33 percent who stated that they were low. This finding also meant that although the frequency and percentage were low, the respondents had to give almost all the statements across the respondents.

Furthermore, teachers' professional competence faced five or 83 percent of the respondents who stated moderate and one or 17 per cent of respondents who said they were low. Finally it was found that teachers' personality competence aspect had a high level of three or 50 percent of respondents and three or 50 percent saying moderate.

The low level of teacher competence is very unlikely to motivate its students to achieve high quality as the ratio pedagogical competence is directly attributable to the knowledge of students [25]. Since teachers are competent in pedagogy, there is no other way that the government can provide assistance to teachers to improve their pedagogical competence. One thing the government can do is to help teachers to improve pedagogical skills by continuing their education to higher levels or assisting them to include teachers at each workshop appropriate to the field of expertise [26].

The teacher's competence in the learning process is very important as this factor is the spearhead of the school to make the student outdoors. Therefore, teachers must have competence in accordance with applicable standards [27]. To identify the problems faced by teachers in improving their competence, interviews are described in this section. Based on interview findings, the following will be explained by the respondents involved in the interview starting from the same opinion about the absence of a problem in the aspect of teacher pedagogy competence.

4. Conclusion

The principals' role significantly affects the ability to succeed in pedagogy of vocational high school vocational school teachers in Padang City. Overall it can be concluded that the principal has a major role in improving the pedagogical competence of teachers and it is necessary that all indicators roles can give a significant effect on the competence of the state vocational high school teacher in the city of Padang.

Table 4. Frequency and Percentage of Respondents Who Respond Based on Teacher Competency Level

Number	Teacher competency	Stage					
		Height		Simple		Low	
		No	(%)	No	(%)	No	(%)
1	Pedagogy competence	-	0	4	67	2	33
2	Personality competence	3	50	3	50	-	0
3	Social competence	5	83	1	17	-	0
4	Professional competence	-	0	5	83	1	17

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