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Aspects of Dholuo Coronal Harmony

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Abstract

Coronal harmony in Dholuo refers to the co- occurrence restriction on dental and alveolar obstruents and nasals. The purpose of this paper is to describe and explain coronal harmony as it manifests in Dholuo. This involves an examination of the phonetic and phonological properties that define coronal harmony in Dholuo. In an Optimality Theory account of coronal harmony in Dholuo, the paper adapts Rose and Walker (2004) surface correspondence constraints CORR-T↔T which demands identity in all respects between segments and CORR- T↔D where voicing may be different but manner and place of articulation must be identical if at all harmony is to be achieved. The phonological feature distributed [dist] is the distinctive feature amongst the coronals. The paper also proposes that some of the morphophonemic alternations attested in Dholuo grammar are motivated by consonant harmony phenomenon.

***Key words**: consonant, harmony, coronal, constraint, optimal candidate, agreement*

1.0 Introduction

This paper seeks to document and analyse coronal harmony in Dholuo in terms of the phonetic and phonological properties that define it. Coronal harmony is more common than any other harmony involving place of articulation (Shaw 1991 and Hansson 2001). Coronal harmony refers to the patterns of agreement for features only relevant to coronals (Rose and Walker 2001). This type of harmony affects the coronal fricatives, such as **/s/** and /ʃ/ in a word, requiring all the coronal fricatives in the word to belong to either [+ anterior] class(s-like sounds) or [– anterior] class (sh-like sounds). Such patterns are found in the Dene (Athabaskan) languages such as Navajo (Young and Morgan, 1987, McDonough, 2003) and Tahltan (Shaw 1991). Various Austronesian languages exhibit consonant harmony among liquid consonants with [r] assimilating at a distance to [l] or vice versa. Western Nilotic languages like Anywa and Pari have root internal coronal harmony (Hansson 2001). This is a co- occurrence restriction on dental vs. alveolar obstruents and nasals. The paper is interested in documenting and analysing the manifestation of this phenomenon in Dholuo.

1.1 Background to the language of study

Dholuo is the 'language of the Luo'. Dholuo belongs to the Western Nilotic group. According to Bender (1989), Western Nilotic languages closely related to Dholuo are Jur Colo, Anuak (Anywa), Shilluk and Luo (Southern Sudan); Acholi, Lang'o (Northern Uganda); Padhola (Western Uganda) and Alur (Northern Eastern Congo and West Nile Province, Uganda). Oduol (1990) confirms the existence of the two dialects of Dholuo and establishes the geographical spread of both dialects. There is Kisumu-South Nyanza hereafter KSN, spoken in a wider geographical area which include Yala, Maseno, Kisumu, Winam, Muhoroni, Mbita, Ndhiwa, Migori, Macalder, Oyugis, Kendu and Bondo divisions (excluding Yimbo locations). The second dialect Boro-Ukwala (B-U) is spoken in Yimbo location of Bondo, Boro and Ukwala divisions.

Dholuo has a total of twenty-six consonants and out of these five are prenasalized compounds which may be regarded as cluster, especially in the underlying representations as they always function as unit phonemes. Table 1 shows consonants classified according to the place of articulation, state of glottis and place of articulation. In each cell where a contrast exists the voiced sound is placed on the right, whereas its voiceless counterpart is on the left.

Table 1: Consonantal phonemes of Dholuo (Adapted from Okombo, 1982 and Tucker,1994)

Place / **Manner**	bilabials	Labio Dentals	Dentals	Alveolars	palatals	labio-velars	Velars	Glottal
Stops	p b			t d	c ɟ		k g	ʔ
Fricatives		F	θ ð	s				h
Nasals	m			n	ɲ		ŋ	
Laterals				l				
Trill				r				
Glides					j	w		
Prenasalised Stop	^{m}b		^{n}ð	^{n}d	^{n}ɟ		^{ŋ}g	

The manner of articulation of dental sounds represented by the symbols [θ] and [ð] in table 1 is controversial in literature. They are referred to as interdental spirants (Odaga,1997), alveolar fricatives (Okombo, 1982), dental affricates (Maddieson, 1984), dental explosives (Tucker, 1994), dental stops (Hansson, 2001) represented with the phonetic symbols [t̪] and[d̪], interdental affricates by Degenshein (2004) who explains the manner of articulation as domain initial strengthening with a difference in articulation in prosodically stronger versus weaker positions, Cable (2009) refers to them as affricate stops. The researcher adopts the symbols [θ,ð] and refers to them as dental fricatives, since the sounds are articulated with the tip of the tongue moving to the upper teeth causing partial obstruction of air flow.

Tucker (1994) notes that there is a cooccurrence restriction between the dentals and alveolar series. It would be interesting to determine the reason behind the non-occurrence. Are there particular phonological and phonetic properties that motivate the occurrence of dentals with dentals while alveolars occur with alveolars yet bar their co oocurrence within a word; yet both dentals and alveolar share the property coronal? Some studies show that these restrictions may be as a result of the shape of the consonantal inventory. Mackenzie (2005) studies Bumo Izon and reveals there is a co occurrence restriction barring implosive and plosive stops from occurring in morphemes and this is attributed to the phonemic inventory. Participating phonemes must contrast in their phonological property. The idea of contrast is then important in the investigation of phonemes. This may mean that the non-contrasting sounds are barred from participating. However, according to Rose and Walker (2004), contrast cannot be the determining factor in selecting participating segment rather all the segments that participate should be highly similar as a factor for their participation. This paper was interested in establishing the phonological property that allows this co occurrence and how contrast applies amongst Dholuo coronals.

Okombo (1982) in the study of morphophonemic alternations prevalent in Dholuo argues that some of the alternations, for instance, change of a final consonant from /l/ to /nd/ in nominal forms cannot be explained by the morphophonemic rules and that there is no phonetically plausible evidence for this change.

(1) Morphophonemic alternations from /l/ to /nd/ (Okombo, 1982)

Nom.sg	**Nom pl.**	Gen. sg	
(a) tíɛ̀lɔ́	tie^{n}de	tie^{n}d	'foot'
(b) tɔ̂:l	tɔ:^{n}dɛ	tɔ:^{n}d	'rope'
(c) dwɔ̂:l	dwɔ̂:^{n}dɛ́	dwɔ̂ :^{n}d	'voice'

The alveolar lateral changes to prenasalized alveolar stop. He overtly calls for further investigation into this type of alternation. Maybe a different rule or phonological process could explain this occurrence. He uses Natural Generative Phonology (Hooper, 1979) which he says cannot satisfactorily account for this alternation. An analysis of the similar and contrastive features would enable us get a phonetically plausible explanation in the two forms. This change is not accidental since it has been attested in more than one word in Dholuo therefore morphologically speaking it would be termed as a regular, unmarked form since its occurrence is predictable. On a basic examination the sound [l] and the alternant [^{n}d] are both coronals.

This paper seeks to argue that some of these morphophonemic changes are motivated by consonant harmony. This paper also examines the phonetic and phonological properties that define coronal harmony in Dholuo and the motivating factors behind the non-occurrence amongst the coronals. An examination would help establish if the co-occurrence restriction is motivated by place of articulation rather than manner of articulation feature.

3.0. Theoretical Framework

This investigation was based on the Optimality Theory (hereafter OT), originally developed by Prince and Smolensky (1993). Different scholars have adapted OT and further elaborated the original work (McCarthy & Prince, 1993; Rose & Walker, 2001 & 2004 and McCarthy, 2002). OT is a linguistic model proposing that observed forms of a language arise from the interaction between conflicting constraints. OT models grammars as systems that provide mappings from inputs to outputs. The inputs are conceived as the underlying representations and the outputs as the surface realizations. OT is theory of phonology in which the rewrite rules as formulated in Transformational Generative Grammar (TGG) and NGP are replaced by constraints based on the output. The idea of constraint based model emanates from Universal Grammar. There are three basic components of OT namely, GEN, CON and EVAL (cf. McCarthy & Prince 1993). GEN the generator supplies or generates an infinite number of candidates, or possible realizations of an input. The candidates include ones identical to the input, slightly different from it, or seemingly unrelated ones. The candidates are possible output forms that are placed for evaluation or assessment using a system of constraints to select the optimal form (the one that best satisfies constraint set). OT supposes that there are no language-specific restrictions on the input. This is called the richness of the base. Every grammar can handle every possible

input. The grammar of a language (the ranking of constraints) determines which of the infinite candidates will be assessed as optimal by EVAL (McCarthy & Prince 1993)

CON is the same in every language but languages differ in the ranking of the CON. OT predicts that there cannot be more grammars than there are permutations of the ranking of the CON. The number of possible rankings is equal to the factorial of the total number of constraints. Two languages could generate the same range of input-output mappings but differ in the relative ranking of two constraints which do not conflict with each other (Prince & Smolensky 1993). There are two types of constraints: faithfulness and markedness constraints. Faithfulness constraints demand that the input and output structures are maximally similar. The observed surface form (the output) match the underlying or lexical form (input) in some particular way, that is , these constraints require identity between input and output forms. This constraint is conservative since it requires the input structure to be preserved in the output. Markedness constraints impose requirements on the structural well-formedness of the output. Each constraint plays a crucial role in this theory. Faithfulness constraints prevent every input from being realized as some unmarked form, and markedness constraints motivate changes from the underlying form.

EVAL the evaluator selects the candidate that best satisfies the constraint system as the actual output. The main proposal of OT is that constraints are violable and they are ranked such that a lower ranked constraint can be violated in the optimal output in order to satisfy some higher ranked constraint. Universal Grammar specifies the set of constraints, but ranking is on a language- specific operation. Whenever there is a constraint conflict, the candidate which violates the lowest ranked constraint is the best. While in a gradient constraint, the candidate which ranks the least is the best. In case of a tie, all the surviving candidates are tested recursively against the rest of the hierarchy. The optimal member of a set is the output.

Once the winner is found, the lower-ranked constraints are irrelevant. This can be illustrated by the following schema where the basic conventions of constraint tableau are listed as well.

Table 2: Basic conventions of a constraint tableau

Candidates	A	B	C	D
Cand 1	*!			*
Cand 2		*!		
Cand 3			**!	
Cand 4 ☞			*	***

Adapted from McCarthy and Prince (1993, p.6-7

Candidates 1, 2, 3 and 4 refer to the various inputs generated by GEN. A, B, C and D refer to constraints. While left-to-right order mirrors the dominance order of the constraints. A dotted line signals that the constraints in question are not ranked with respect to each other. Violation of a constraint is indicated by an asterisk *. Satisfaction is indicated by a blank cell. The symbol [!] indicates fatal violation, the one that is

responsible for a candidate's non-optimality. It highlights the point where the candidate in question loses to other more successful candidates. The pointing finger [☞] indicates the optimal candidate. Shading indicates the irrelevance of the constraint to the fate of the candidate. A loser's cells are shaded after the fatal confrontation and the winner's when there are no more competitors.

4.0 Methodology

The study adopted the analytic research design. The researcher not only described the data as it is, but also attempted to analyse and explain the consonant harmony phenomena as it occurs. The study population included all Dholuo words. The sampled population included spoken texts consisting of transcripts of digital audio material in Dholuo which was recorded from radio programs aired in a local station, Radio Lake Victoria. The data collected consisted of words which were selected, transcribed phonemically, and organized thematically according to the articulatory features. Library research was used in collating information on theoretical literature.

5.0 Presentation and analysis of Coronal Harmony Data

Coronal sounds are produced by the blade of the tongue raised towards the front teeth, the alveolar ridge or the hard palate (Katamba, 1989). Coronal sounds in Dholuo are alveolars and the dentals. The other coronals like palato- alveolar and retroflex are not found in Dholuo phonemic inventory. In Dholuo, there is a co-occurrence restriction between the alveolars and the dentals, i.e alveolars cannot co-occur with dentals in one word. The alveolar sounds in Dholuo are / t, d, s, l, r, n, ^{n}d/ while the dental sounds include /θ, ð, ^{n}ð/. The dentals /θ, ð, ^{n}ð/ cannot co-occur with these particular alveolar sounds / t, d, ^{n}d/ in a single word. The other alveolar sounds /s, l, r, n / co- occur with the dentals.

5.1 Dental vs dental contrasts

A dental consonant is articulated with the tongue against the upper teeth. The upper teeth acts as the passive articulator while the tip of the tongue as the active articulator. In interdentals, the airflow is restricted (impeded) when the tongue-tip is caught between the teeth. These dental sounds may be either voiced or voiceless. Dental sounds in Dholuo usually co-occur with each other. This can be illustrated as follows:

Data set 1: [θ-θ] voiceless vs. voiceless dental fricative

Word	**orthography**	**gloss**
a) /θôθ/	thoth	'many/much'
b) /θieθ/	thieth	'treatment'
c) /ɔθî:θ/	othith	'reed'
d) /θô:θ/	thûth	'weevil'

Data set 1 above illustrates the voiceless dental fricative contrasting with a similar sound **/** θ-θ/. The consonantal phonemes in the data correspond in terms of place of articulation and voice specification. Rose and Walker (2004) posit that in order to have consonant harmony then a language must have both highly

ranked surface correspondence constraints and highly ranked IDENT-CC constraints that require surface segments in correspondence with one another to share identical specifications for some feature. The IDENT-CC constraint works together with these other constraints:

(2) ID-CC [dist] adapted from Mackenzie (2005)

Surface segments in correspondence with one another agree for the feature distributed (dentals are [+dist] while alveolars [-dist].

(3) CORR [θ↔θ]

Surface segments be identical in all aspects (ensures that the dental-dental contrast is established).

(4) ID-CC [voi]

Maintain identity of voice specification. One violation is incurred for each segment that differs in voicing between the input and output.

(5) ID-IO [+dist]

Input and Output correspond for feature [+ dist]. This demands that dental segments in the input are realized as dental segments in the output.

(6) Input [θɔ̂:θ] 'many/much'

θɔ̂: θ	ID-CC[dist]	CORR θ↔θ	ID-CC[VOI]	ID-IO[+dist]
a. θɔ̂:t	*!	*		*!
b. θɔ̂:ð		*	*	
☞c. θɔ̂:θ				
d. ðɔ̂:ð		*		

In the analysis, (a) fails because it violates ID-CC [dist] which constrains dentals from occurring with alveolars in the output. Dholuo restricts this occurrence especially where there are contrastive dental or alveolars. This is a fatal violation. (b) is a faithful candidate to the dental feature [+ dist], however, fails to satisfy surface correspondence constraints between the input and the output in terms of voicing (CORR θ↔θ and ID-CC [VOI]', (c) is the optimal candidate as it incurs no violations, harmony results when highly ranked faithfulness constraints are satisfied especially those that demand surface segments to be in correspondence in each other. (d) incurs violations in terms of input-output correspondence in terms of voicing so it is outranked by (c) in that front.

Data set 2 : [ð-ð] voiced vs. voiced dental fricative

word	**orthography**	**gloss**
a) /ðɔ́:ðɔ̀/	dhodho	'suckle'
b) /ðé:ðé/	dhedhe	'kind of a bird'
c) /ðé:ðó/	dhedho mach	' to make a bonfire'

The data set 2 illustrates the co-occurrence of voiced dental fricatives /ð-ð/. The surface correspondence CORR-T↔T (Rose and Walker, 2004), applies here too, however, it is adapted to constrain output to only the voiced dental segments thus [CORR-ð↔ð], surface segments surface segments in correspondence relations must be voiced dentals. In a tableau analysis, ID-CC constraints are applied as in (6) which are faithfulness constraints.

(7) Input [ðɔ́:ðɔ̀] 'to suckle'

/ðɔ́:ðɔ̀/	ID-CC[dist]	CORR-ð↔ð	ID-CC[voi]	ID-IO[+dist]
a. ðɔ́:dɔ̀	*!	*!		*!
☞b. ðɔ́:ðɔ̀				
c. ðɔ́:θɔ̀		*	*	
d. θɔ́:θɔ̀		*!	*	

In the tableau, candidate (a) incurs many violations the worst of them being ID-CC [dist] that requires segments to agree with one another for the feature distributed and in this case both must be [+dist] but /d/ is [-dist] creating a disharmonic form. (b) is the winner as it satisfies ID-CC and surface correspondence constraints. (c) and (d) though faithful to the feature distributed lose out due to failure to correspond to the input-output voice specification and even the surface voice specification demands.

According to Rose and Walker (2004) surface correspondence constraints CORR-T↔T that demands surface structures to be identical must be the highly ranked faithfulness constraint if harmony is to be achieved. These constraints ensure that all consonants are in total correspondence in terms of place, manner and voicing creating total or complete harmony. According to MacEachern (1997) consonants should be identical in all respects. This concurs with the proposition by Rose and Walker (2004) about surface correspondence. MacEachern (1997) proposes a constraint referred to as BEIDENTICAL that explicitly demands total identity between consonants. Dholuo data sets 1 and 2 attest to this fact. He posits that Complete Identity Effects (CIEs) arise when multiple different IDENT-CC constraints work together so that disagreement on any feature leads to dissimilation. Dholuo data reveals that dentals can interact but may not necessarily be identical in every sense. This can be exemplified in Data set 3.

Data set 3: Co occurrence of voiced vs. voiceless dental fricative

word	**orthorgraphy**	**gloss**
a) /θe:ðo/	thedho	'forge iron'
b) / θÍèðɔ/	thiedho	'to treat'
c) /ðɔ̂:θ/	dhoth	'suckling'
d) /ðô:θ/	dhuth	'causing conjunctivitis'

Data set 3 illustrates the co-occurrence of the voiced and voiceless dental fricatives in both initial and final positions in a word. These two sounds are contrastive in that /θ/ is voiceless while /ð/ is voiced. The phonology of the language permits this occurrence. Therefore the surface correspondence of segments need not be in all features and but at least some. Coronal harmony is as a result of identity in some respects and not necessarily complete identity.

Rose and Walker (2004) propose another surface correspondence constraint:

(8) CORR-T↔D

This constraint demands correspondence between segments that have same manner and place but differ in voicing (adapted from Rose and Walker, 2004).

(9) Input [θe:ðo] 'to forge iron'

θe:ðo]	ID-CC[Dist]	ID-IO[+dist]	ID-CC[voi]	CORR-[θ/ð]	CORR-C↔C
a. θe:do	*!	*!		*!	*
b. ðe:ðo			*	*	
c. ☞θe:ðo					*
d. θe:θo			*	*	

Candidate (a) violates most constraints, therefore a fatal candidate, violates co occurrence restrictions between dentals and alveolars. (b) is unfaithful to input-output correspondence in voice specification and surface correspondence demands on contrast on voice specification c) the demand on complete identity is not highly ranked since surface forms from Dholuo data reveal that voice contrasts between dentals within a word have been attested. (c) the winner, faithful to ID-CC constraints.(d) loses out on input-output correspondence in

voice specification . As long as they demand of place of articulation constraints are met; the phonology of the language permits disagreement in voice specification between the surface forms.

An interesting observation amongst the Luo who speak the B-U dialect is in the word 'thieth' /θIêθ/ which means treatment. It is pronounced which as chieth /ciêθ/ as illustrated in (9).

(10) Onyango nodhi e chieth (BU dialect version of thieth "treatment)

'Onyango went for treatment (in hospital)'

The words /ciêθ/ vs. /θiêθ/ both mean'treatment'. This gives a contrast of [c- θ] rather than [θ-θ]. This dialectal variant causes dissimilation because a palatal contrasts with a dental. Dissimilation is a phonological process whereby sounds which are similar and therefore difficult to articulate are made more auditorily distinct or perceptible. This dissimilation causes disharmony as the two consonants no longer match in the phonological properties. The phonemes /c/ a palatal stop and /θ/ dental fricative have both been used in the same context (word-initial) to bring the same meaning. If [θiêθ] is hypothesized to be the Proto-Luo word then analysed in OT terms:

(11) input [θiêθ]

θiêθ	ID-CC[dist]	CORR-θ↔θ	ID-IO[dist]	ID-CC[voi]
a. θiêθ				
b. ciêθ	*	*!	*!	

i) /c.. θ/ disharmonic output- palatal...dental

ii) /θ.. θ/ harmonic output dental... dental

The phonemes /c/ and /θ/ are in free variation in this context since the use of either of the does not result into a change in meaning. This free variation is attested only in B-U dialect. In a different context, /c/ and /θ/ are distinct phonemes (resulting into a difference in meaning), as can be seen in the minimal pairs /cô:θ/ 'completely' and / θô:θ/ 'weevils'

5.2 Alveolar contrasts

Data set 4 : Alveolar vs alveolar contrasts

Word	**orthography**	**gloss**
(a) /tó:tó/	tutu	'pus'
(b) /té:tnì/	tet-ni	'shivering'
(c) /te:do/	tedo	'to cook'
(d) /dódó/	dodo	'kind of music'
(e) /dó:dó/	dudu	'name of a person'
(f) / dé:dé/	dede	'insect'
(g) /dûtō/	duto	'all'

From the data above (a) and b) illustrate /t-t/ co-occurrence, while (c) illustrates /t-d/, then (d),

(e) , (f) illustrate /d-d/ and (g) illustrates /d-t/. This can be summed up as:/ d-t/, /t-t/, /t-d/, and /d-d/ contrasts are all allowed in the language in both initial and final positions.

The data sets 1,2 and 3 reveal that dentals contrast with dentals while data set 4 shows alveolars contrast with alveolars. For instance, /t-d/ and /θ-ð/ contrast but not */t- ð/ or */θ-d/ in words like, /tedo/ and /θeðo/ but not */θe:do/ or */teðo/ respectively.

(12) A summary of co-occurrences patterns between alveolars and dentals

a. d-t t-t t-d d-d

b. ð-θ θ-θ θ-ð ð-ð

c. *d-θ *t-θ *t-θ *d-ð

d. *ð-t *θ-t *θ-d *ð-d

From the summary (a) and (b) are allowed combinations while (c) and (d are disallowed. However, there are some compound words in the language which permit certain disallowed combinations.

Data set 5: Alveolar and dental combinations

(13)	Word	Orthography	Gloss
	(a) /ðɔ:t/	dhoot	‘door’
	(b) /ðɔ́:ɔ́dÌ/	dhoudi	‘doors’

Data from Dholuo reveal combinations */ð-t/ and */ð-d/ which are ordinarily disallowed in the language since they violate the dental /alveolar contrast. This could be explained by the fact that the words are formed from two different words in (a) dhoot which is derived from dhog ot ‘ house’s mouth’ literally which means ‘ a door’ as a compound noun while (b) is the plural form dhog udi ‘houses’ mouths’ which means ‘doors’. In the compound word, when /g /which is the final consonant in the first compound is elided the vowel /ɔ/ is lengthened to compensate for the loss of the consonant /g/ and vowel / ɔ/, /ðɔ:g ɔt/ becomes /ðɔ:t/. This is a disharmonic output since a dental occurs with an alveolar.

5.3. Contrastive patterns of alveolars and dentals

As already mentioned dentals co-occur with dentals while alveolars with alveolars, however, in the nasals and liquids series there are alveolars /l,r,n/ and yet no dentals */l̪,r̪,n̪/ to contrast with .

Table 2: Contrastive patterns of alveolar and dentals in Dholuo

	Dentals	Alveolar
Voiceless	θ	t
Voiced	ð	d
Prenasal stop	^{n}ð	^{n}d
Nasal		^{n}
Liquids		r,l

From the table it can be observed that in Dholuo there is alveolar nasal [n] and no dental nasal; alveolar liquids [r,l] and no dentals liquid to contrast with. The contrastive alveolar consonants [t,d] will trigger harmony unlike the redundantly alveolar sonorants like [n], [l] and [r]. Cases of alveolar nasal and alveolar liquids co occurring with the dentals were attested in this study.

Data Set 6 :

	word	orthography	gloss
a)	θó:nɔ̀	thuno	‘breast’
b)	ðá:nɔ̀	dhano	‘human being’
c)	θû:ð-nō	thudhno	‘numbness’
d)	ló:θ-nì	lothni	‘to be loose’
e)	ló:ð-nÌ	ludhni	‘to be in want’

The data reveals that the nasals and liquids are blocked from participating in the co-occurrence restriction.The nasal [n] freely co-occurs with both dentals and alveolars without incurring any violation of the co occurrence restrictions. Dental nasals are not realised in Dholuo even where an alveolar nasal appears close to a dental sound as in examples (d) and (e). This could be due to the fact that the dental and the alveolar do not fall within the same syllable. However, in Anywa, a Western Nilotic language, [n] may not occur with a dental stop, rather a dental nasal [n̪] appears allophonically in roots that contain the dental stops (Reh,1996).

(14) Dental vs. alveolar contrasts from Anywa (Reh, 1996)

a) n̪uḏo ‘to lick’ c) nuudo ‘to press something down’

b) t̪uḏ ‘ropes’ d) tuud ‘pus’ e) oḏoon̪ ‘mud’

(15) Dental / alveolar contrast in Päri (Andersen, 1988)

a. t̪ʊɔn̪ ‘male’

b. n̪ɔt̪ ‘sucking’

c. ḏa:n̪-ɛ ‘person,ergative’

The data from Anywa and Päri show that the nasal is not barred from participating in the dental /alveolar harmony nor is neutralized like in the case of Dholuo, instead an allophone which is a dental nasal [n̪] is realized. The dental nasal therefore contrasts with the alveolar nasal [n]. Contrast is therefore not the only factor to be considered in selecting participant in harmony. The notion of contrasts obtains in Anywa and Päri

but not in Dholuo. Dholuo lacks a dental nasal counterpart to contrast with the alveolar, however, it does not create an allophone therefore allowing 'disharmonic' forms when the alveolar nasal becomes neutral thereby blocking the propagation of harmony property. The lack of a dental nasal in Anywa is an accidental gap, that means it is not required by the system of contrasts in the language while the lack of a dental nasal in Dholuo is a systematic gap and structure preservation will rule out the creation of a [+ distributed] dental nasal (Mackenzie, 2005).

The lack of a dental nasal in Dholuo is debatable. In a prenasalised dental stop [ⁿð] there is possibility of articulating the nasal at the dental region thereby creating a dental nasal in that environment. This is a marked cluster. This can be illustrated as follows:

Data set 6

a)	n̪ðɪ:wa	ndhiwa	'place'
b)	n̪ða:n̪ðʊ	ndhandhu	'taste'
c)	n̪ðɪ:n̪ðɔ	ndhindho	'to feel pins and needles'
d)	ɔn̪ðʊ:n̪ðɔ	ondhundho	'bone marrow'

In the articulation of the prenasalized dental stop the tongue-tip makes contact with the upper teeth air is blocked as a result. The impeded air is then released through the nasal cavity. There may be no dental nasal in the system of contrasts but it occurs as an allophonic variant in a prenasalized compound, [n̪] rather than [n]. The initial nasal sound is not articulated at the alveolar ridge; rather the tongue tip touches the dental region. This creates a dental nasal allophone due to assimilation at the place of articulation which is the dental region. This kind of assimilation is referred to homorganic nasal assimilation; where a nasal preceding a consonant becomes more like it (Katamba, 1994).

In conclusion, Dholuo data reveals that the notion of contrast applies only if there is a contrastive sound in the inventory. Lack of a dental nasal in Dholuo inventory blocks the propagation of co occurrence restriction. Alveolar nasal therefore cooccurs with dentals . Literature on Bumo Izon an Ijoid language reveals that the voiced velar and labio velar stops do not participate because they lack a partner at the same place of articulation that differs in terms of pulmonic /implosive distinction (Mackenzie, 2005). Consonant harmony therefore depends on the phonemic inventory of a language. Anywa may be a Western Nilotic language just like Dholuo but its system of contrasts differs in that a dental nasal allophone is created to contrast with alveolar nasal. In Anywa, contrast is a factor in coronal harmony. Phonological processes such as assimilation are language specific since a phenomenon may obtain in one language but may be unattested in another. The two languages are related in a diachronic perspective but their phonemes pattern differently.

5.4 Root internal coronal harmony

(16) Root final alternations that lead to coronal harmony in Dholuo

Nom.sg	Nom pl.	Gen. sg		
(a) tíɛ̀lɔ́	tiende	tiend	[t..nd]	'foot'
(b) tɔ̂:l	tɔ:ndɛ	tɔ:nd	[t..nd]	'rope'
(c) dwɔ̂:l	dwɔ̂:ndɛ́	dwɔ̂ :nd	[d...nd]	'voice'

In (16) root final consonant /l/ changes to /nd/. The alveolar lateral /l/ changes to a prenasalised alveolar stop to match with initial alveolar stops /t/ and /d/. The shared feature is [- continuant, - distributed] while /l /is [+ continuant, +distributed]. This results to coronal harmony. The root final stops are a result of morphophonemic alternations in the grammar of Dholuo (Okombo, 1982). Most Western Nilotic languages make use of the root-final alternations in their inflectional and derivational morphology (Andersen 1988, 1999; Tucker 1994; Reh 1996; Okombo, 1982).The root final stops are a product of final mutation combined with affixation match the dental or alveolar property of the initial stop. Some of these morphophonemic alternations are an attempt by the phonology of Dholuo to harmonize consonants within a word. The consonants become more similar in their phonological properties and in this case both initial and final.

6.0 Conclusion

Coronal harmony in Dholuo occurs amongst the dental and alveolar consonants. There is a co occurrence restriction barring alveolars from occurring with dentals. The defining phonological property here is the feature distributed [dist]. Alveolar consonant are distinguished by the feature [-dist] while the dentals are distinguished by the feature [+dist]. There are exceptional cases where dentals co occur with alveolars and this could be attributed to the contrasts in the system. The co occurrence restrictions apply only in cases where the dentals contrast with alveolars. However, in the cases of alveolar nasal there is no dental nasal to contrast with. It therefore co occurs with dentals.

7.0 References

Andersen, T. (1988). Consonant alternation in the verbal morphology of Päri. *Afrika und Übersee* 71, 63-113

Andersen, T. (1999). Consonant alternation and verbal morphology in Mayak (Northern Burun). *Afrika und Übersee* 82, 65-97.

Bender, M.L. (1989). *Topics in Nilo-Saharan linguistics Volume 3* Hamburg: Helmut Buske Verlag.

Cable, S. (2009). Some basic facts about the Dholuo language. Structure of a non-Indo-European language. Ling 748, 1-13.

Degenshein , R. (2004). Dholuo interdentals and domain initial strengthening, *From sounds to sense*: June 11-June 13, 2004. MIT C-19.

Efere, E .(2001). The pitch system of the Bumo dialect of Izon. *Current research on African languages and linguistics*, Suzzane Gessner , Suny Young Oh, and Kayono Shiobara eds. UBC working papers in Linguistics 4.

Hansson, G.O. (2001). *Theoretical and typological issues in consonant harmony.* Berkeley: University of California.

Hooper, J.B (1979) *An introduction to generative phonology*. New York: Academic Press.

Katamba, F. (1989). *Introduction to phonology.* London: Longmans.

MacEachern, M. (1999). *Laryngeal cooccurence restrictions*. New York: Garland.

Mackenzie, S. (2005). *Similarity and contrast in consonant harmony systems.* University of Toronto. Toronto working Papers in Linguistics 24: 169-182.

Maddieson, I. (1984). *Patterns of sounds*. New York: Cambridge University Press.

Mcdonough, J.M. (2003). *The Navajo sound system*. Dordrecht: Kluwer.

McCarthy, J., & Prince, A. (1993). *Prosodic morphology I: Constraint interaction and satisfaction*. (RUCCS Technical Report, 3) Piscataway: Rutgers Center for Cognitive Science, Rutgers University.

McCarthy, J. (2001). *A thematic guide to Optimality Theory*. Cambridge: Cambridge University Press.

Odaga, A.B. (1997). *English-Dholuo dictionary.* Kisumu: Lake Publishers & Enterprises Ltd.

Oduol, J.H.A. (1990). Dholuo dialects: Synchronic state and some historical inferences, Unpublished PHD Thesis. University of Nairobi.

Okombo, D. (1982). *Dholuo morphophonemics in a generative framework.* Berlin: Dietrich Reimer Verlag.

Prince, A., & Paul Smolensky.(1993). *Optimality Theory: constraints interaction in a generative grammar*. Piscataway: Rutgers Center for Cognitive Sciences, Rutgers University. Available at http://roa.rutgers.edu/files/537-0802/537-0802-PRINCE-O-O.PDF . Accessed on 7th July 2012.

Reh, M. (1996) *Anywa language: description and internal reconstruction.* Koeln: Ruddiger Koppe Verlag.

Rose, S., & Walker, R. (2000). Consonant agreement at a distance. *Paper presented at NEIS* 31, Georgetown University, October 7, 2000.

Rose, S., & Walker, R. (2004). *A Typology of consonant agreement as correspondence*. Language 80: 3 475-531. University of Carlifornia, San Diego and University of Carlifornia.

Shaw, P. (1991). *Consonant harmony systems: The special status of coronal harmony, (Ed*,). Prunet: Academic Press.

Tucker, A. N. (1994). *A grammar of Kenya Luo (Dholuo).* Koln: Rudige Koppe Verlag.

Walker, R. (2000). Long distance consonantal identity effects. *Papers presented at WCCFL 19*, Los Angeles, February, 2000.

Young, R., & Morgan, W. (1987). *The Navajo language*. Albuquerque, University of New Mexico Press.

The Profile of Mathematical Knowledge for Teaching and Mathematical Beliefs of Pre-Service Primary Teachers

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This case study was aimed at obtaining description of profile of pre-service primary teachers on mathematical knowledge for teaching and mathematical beliefs developing in traditional learning and problem-based learning. Knowledge for teaching is known with the term content knowledge and pedagogical content knowledge. But in the development, the knowledge for teaching has specialization in mathematics. Mathematics educator is demanded not only to be able to teach mathematics content, but also to master various mathematics representation, know unusual way in mathematics solving, and be able to give justification that students' way is wrong and give appropriate direction. The situation of pre-service primary teachers in this study was observed after they followed traditional learning and problem-based learning. Problem-based learning was designed to give the pre-service primary teachers experience in mathematics problem solving related to material, teacher, and students in mathematics learning. The comparing of two learnings was done to know the profile of mathematical knowledge for teaching and mathematical beliefs of the pre-service primary teachers.

Keywords: mathematical knowledge for teaching, mathematical beliefs, pre-service primary teachers

Introduction

The importance of assessment of teacher competence has been acknowledged by the government, as stated in Regulation of The Minister of National Education of Republic of Indonesia Number 16 Year 2007 concerning Teacher Academic Qualification Standard and Competence. Teacher Competence Test (TCT) is carried on to measure professional and pedagogic competence so that nationally, the teaching quality of teacher can be known and teacher profession development can be mapped. In 2013 the total average of national Teacher Competence Test was only 47,84 of the 100 scale. The score was not much different from the the one of 2012, which was 45,85. The recent average of national TCT (year 2015) is 53,02 lower than the target of 55.

The government keeps doing efforts to improve the quality of teacher. Refering to the opinion of Hill, Ball, and Schilling (2008), the improvement of teaching knowledge which covers content knowledge or professional competence and pedagogical content knowledge or pedagogical competence can be done not only

in teacher profession development program, but also in teacher education program. So, to result a competent teacher can begin from the teacher training program s/he joins.

Teacher education has an objective to supply pre-service teachers (PSTs) with teacher qualifications. Someone's experience in teacher education has an effect to strengthen his identity as a teacher in the future (Grevholm, Millman, & Clarke, 2009). The experience is reflected in the curriculum used by the education institution. Generally, teacher education curriculum contains lecture material, pedagogical knowledge, and practice. Mastery of material when related to teacher competence means professional competence, pedagogical knowledge and practice as pedagogical competence.

The curriculum which is dominating in a teacher training institution depends on the policy made by each country to prepare its human resources to be teachers. According to Ball (2000) it is important to combine content knowledge with pedagogical content knowledge in teacher training, as provision of PSTs fo face the real challenge as teachers. The combination of knowledge will be able to improve the teaching knowledge of teacher candidates simultaneously (Welder & Simonsen, 2011).

The development of recent study on content knowledge and pedagogical content knowledge, has specialized on mathematics material. This specification is caused by the complexity of knowledge a teacher should have when teaching mathematics. According to Schoenfeld and Kilpatrick (2005) teaching mathematics needs specific knowledge. The knowledge demands teacher not only to master content and be able to teach it, but also to have knowledge such as representation effectivity of concept in learning, unusual strategy in solving mathematics problem, understanding students' thinking, and so on. This is strengthened with study conducted by Ball, Hill, and Bass (2005); Hill, Rowan, and Ball (2005); and Tatto, Schwille, Senk, Ingvarson, Peck, and Rowley (2008) that mathematical knowledge for teaching (MKT) consisting of mathematics content knowledge (MCK) and mathematic pedagogical content knowledge (MPCK) is important factor in mathematics success of students in school.

The following is one of proofs writer can give that besides the TCT result which is still under the national average target, the test results of professional competence and pedagogical competence or known as teaching knowledge (Shulman, 1987) of the teacher candidates specialized on mathematics content need attention as well.

Thirty-five (35) PSTs of final semester were given questions to obtain preliminary description of MKT related to MCK and MPCK. The following are questions adapted from Ma (1999),

Known, division operation:

$$2\frac{1}{4}:\frac{1}{2}=$$

(a) Calculate the above fraction division.

(b) Imagine you are teaching fraction division. To make it is more meaningful for students, you relate it to the real world or story question. What will you tell relating the problem $2\frac{1}{4}:\frac{1}{2}=$

The above question expected the PSTs to apply their knowledge of the procedure of calculating fraction division and gave representation of the operation. The study of Ma (1999) on 23 teachers in US and 72 teachers in China showed a result that 43% teachers in US were able to solve question (a) and only 4,3% question (b), able to give meaning of fraction division but were still wrong pedagogicly. 100% teachers in China answered question (a) correctly with various ways of answer, and 90% of them correctly answered

question (b), teacher were able to give meaning and various examples. While, in this preliminary study, the percentage of teacher candidates answering question 1.a correctly was 97% with the sameness of way, namely $2\frac{1}{4}:\frac{1}{2}=\frac{9}{4}:\frac{1}{2}=\frac{9}{4}\times\frac{2}{1}=\frac{18}{4}=4\frac{2}{4}=4\frac{1}{2}$.

The PSTs' calculating results which approached 100% with such a same way showed that lectures in teacher training program did not adequately facilitate the emerging of various calculation strategies. The teacher educators tended to use speech to transfer knowledge so that teacher candidates followed one given way.

Next, for question (b), only 1 PSTs was able to give meaning for problem $2\frac{1}{4}:\frac{1}{2}$: with example of case :

Mother buys $2\frac{1}{4}$ *Kgs of sugar and will make cake in some baking pans. If each baking pan needs* $\frac{1}{2}$ *Kgs of sugar, how many baking pans can mother make?*

The case given above was similar to the case example given by teacher in US showing that the explanation had been appropriate but still had problem pedagogic. The answer of $4\frac{1}{2}$ baking pans of cake, will drive question; are there various shape of baking pan? Baking pan was divided into two?

Result (b) showed that PSTs in the preliminary study still found difficulty in presenting logical case pedagogic. The PSTs' difficulty of number 1b was identified by McLeod & Newmarch (2006) as difficulty in giving fraction representation. The finding in the preliminary study was in line with the finding of Widjaja & Stacey (2009) that content knowledge and mathematics pedagogy of PSTs need improvement.

The development of MKT in teacher training program can be an alternative, since teacher program is a transition phase from high school where an adult PSTs joined minimum education to become a teacher. The process of teacher education enables PSTs to learn as self-evident and do self-reflection (Kennedy, 1999), teacher candidates can recheck the knowledge they have and balance their experiences (Kiely, Sandmann, & Truluck, 2004; Kajander, 2007), important period of belief growth (Philipp, 2007), PSTs experience change of beliefs in mathematics (Oughton, 2009), and adult learners have been mature so that they have higher self confidence (Ashun & Reinink, 2009).

Besides, according to Barrows & Tamblyn (1980) and Levin (2001) the form of learning in teacher training program which is student-centered can make recent learning relevant to the learners' need. One of such kinds of learning is Problem-Based Learning (PBL). PBL approach has an objective to get integration of knowledge concerning with problem, and improve or apply the problem solving skill.

A study, according to Thompson (Philipp, 2007) needs to consider the interrelatedness between belief and knowledge. Many researches have shown that there is relationship between belief and knowledge. According to Moursund (2005), the educator of PSTs should know mathematics knowledge level of the teacher candidates to help the improvement of their mathematics expertise. The mathematics expertise is affected by mathematics belief they have. Refers to Schmidt and Kennedy (1990) someone's belief can affect not only on pedagogic choice but also content choice. Therefore this study investigated the description of interrelatedness between mathematical beliefs, MCK, and MPCK owned by PSTs of two classes on teacher training. The two classes were teacher-centered class with traditional learning and student-centered class with PBL. This was conducted as an effort to respond the statement of the Minister of National Education of Republic of Indonesia, Baswedan (2014) that Indonesian education is under emergency situation, one of which is caused by the low TCT results. According to researchers, improvement can be begun from teacher training

program by preparing PSTs who are reliable in profession competence and pedagogy, especially mathematics. The improvement of competence quality was done by changing the mathematical beliefs of PSTs through learning which related to teachers' work and students' thinking, namely PBL .

Mathematical Knowledge for Teaching

Mathematical Knowledge for Teaching (MKT) according to Ball, Thames, and Phelps (2008, p. 395) is *mathematics knowledge that teachers need to carry out their work as teachers of mathematics*. This mathematical knowledge is used by educator in class to yield teaching and improvement on learners (Hill, et al. 2008). Teaching task can be improved with KTM, so according to Powell and Hanna (2006), KTM is a kind of knowledge which is applied in special context to help students develop mathematics ideas and reasoning.

Projects on Learning Mathematics Teaching (LMT) in Michigan University developed MKT models based on Shulman's concept, by clarifying the difference between CK and PCK and developing measurement of MKT. Based on analysis of Ball, et al. (2008) on basic knowledge of teaching mathematics, Shulman's categories of CK and PCK are called Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK). SMK can again be categorized into Common Content Knowledge (CCK), Horizon Content Knowledge (HCK) and Specialized Content Knowledge (SCK). While PCK is categorized into Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT) and Knowledge of Content and Curriculum (KCC).

Beside LMT, other projects were also done by Teacher Education And Development Study in Mathematics (TEDS-M) which developed KTM assesment in teacher education enclosing assesment of belief. Conceptual framework used by TEDS-M concerning KTM, were Mathematics Content Knowledge (MCK) and MPCK (Mathematics Pedagogic Content Knowledge). MCK framework used by TEDS-M was based on TIMSS assesment frame using cognitive domain, namely *knowing*, *applying*, and *reasoning*. MPCK framework has three sub-domain, namely mathematics curricular knowledge, knowledge of planning mathematics, and knowledge of enacting mathematics.

This MCK research on PSTs was focused on teacher candidate mathematics material mastery, thus MCK was meant as ability to give definition in mathematics (CCK/*knowing*), represent mathematics idea appropriatelly (SCK/*applying*), and make connection of interconnected mathematical ideas (HCK/*reasoning*). MPCK was meant as knowledge related to presentation of mathematics material so that it is acceptable for students. The indicators of this ability cover: ablity to understand structure and interrelatedness in mathematics topic (mathematical curricular knowledge), establish various representation/method/procedure of mathematics to explain (enacting mathematics for teaching and learning), and anticipate students' thinking from misconception (knowledge of planning for mathematics teaching and learning).

Mathematical Beliefs

Belief is identified by Philipp (2007, p. 258) as *the lenses through which an individual looks when interpreting the world and as such affects the way one interacts with the world*. McLeod (1992) and Goldin (2002) stated that belief is a part of affective domain beside feeling and mood. In mathematics education context, feeling and mood such as worry, self confident, frustation, and comfort all are used to describe responds to mathematics assignment. While Thompson (Philipp, 2007) contended that belief is a part of conception, which is mental structure covering belief, meaning, concept, proposition, rule, picture mental, and preference.

According to Törner and Pehkonen (1999), belief is a combination of conclusions about various phenomena and naturalness of experience someone has and initial perception existing in the surrounding area. According to Underhill (Leder, et al. 2002) belief on mathematics is the summary of four beliefs, namely (i) beliefs on mathematics as discipline, (ii) beliefs on learning mathematics, (iii) beliefs on teaching mathematics, and (iv) beliefs on our self in context where the matematics learning occurs. Mathematical beliefs according to Ernest (1989) is a view or conception of mathematics naturalness, model or view of mathematics teaching naturalness, and model or view of mathematics learning process.

The study conducted by Mosvold and Fauskanger (2013) broadens the category of teacher beliefs by adding belief in MKT in the context of mathematics teacher in Norway.

Table 1 Extention of Beswick's Categories of Teacher Beliefs

Beliefs about the nature of mathematics	Beliefs about mathematics teaching	Beliefs about mathematics learning	Beliefs about MKT
Instrumentalist	Content for performance	Mastery of skills	Remembering content
Platonist	Content with understanding	Construction of understanding	Understanding content
Problem Solving	Learner focused	Autonomous exploration	Adjusting and differentiating

Source: Mosvold and Fauskanger (2013)

Teaching reformation will not happen without change of mathematical beliefs and learning. Many teachers can have the same knowledge, but one can have orientation on problem solving and the others tend to be dydactic in approach. Therefore, the keys of beliefs components for mathematics teacher are (Ernest, 1989):

1. View or conception of the essence of mathematics
2. Model or view of the essence of teaching mathematics
3. Model or view of the mathematics learning process

In the view of insrumentalist mathematics is a collection of facts, rules, and skills used to achieve final goal. Mathematics is a collection of rules and facts which are beneficial but not interrelated each other. Platonist views mathematics as knowledge which is static but is a whole unity of knowledge. Mathematics is a knowledge which is discovered, not created. The third kind of view, problem solving or constructivist views that mathematics is dynamic, a field that broaden continuously from creation and invention, and culture

product. Mathematics is the process of investigation and finding out, not final result; the obtained results are open for improvement (Ernest, 1989).

Introduction The Correlation of Mathematical Knowledge for Teaching and Mathematical Beliefs

Philosophical view about the role of educator in learning with the orietation on teaching effects divides 3 types of educator. First, educator as insructor stressing on the mastery of skill with expected abililities. Second, educator as explainer having orientation on conceptual understading with whole knowledge. Third, facilitator having trust on problem posing and solving. According to Ernest (1989), the role of educator as instructor representing instrumentalist philosophy is the lowest level, educator as explainer representing platonist philosophy and educator as facilitator representing philosophical view of problem solving is the highest level of educator role. However, the development of educator role is influenced by belief, social context, and thinking level. If beliefs can be determined and social context is a choice, then key factor is on thinking level. The higher the thinking level, such as self evaluation, it wil drive the use of beliefs in someone's practice.

According to Luft & Rehrig (2007), experience PSTs get during teacher training program will affect on their beliefs when they become teachers. Further, Schmidt, Burroughs, and Cogan (2013) conducted research on elementary school teachers in 17 countries and found significant correlation between the lectures teachers took when joining teacher preparation program and self preparation to teach. Moursund (2005) stated that it is important for educators of elementary school PSTs to know the mathematics expertise level of PSTs so that it can help their mathematics expertise improvement. The expertise were identified as mathematics content and mathematics maturity. Mathematics content are among others learning various procedures of arithmetics, algebra, and geometry and how to use procedure to solve mathematical problem. The characteristics of mathematics maturity are comprehension area, problem solving, theorema proving, problem posing, making connection of mathematics in the setting of knowledge broadness and newness, identifying problem solution, giving presentation, and making connection of mathematics ideas.

Research on MKT levels of PSTs in analyzing students' work result and way of thinking was conducted by Somayajulu (2012). The level of teacher candidates were (0) *Naive*, (1) *Developing*, (2) *Mature*. On level of *mature,* mathematicaly and pedagogicly, the strategies used were accurate and had keys of concept and idea, many strategies given were relevant to solve students' misconception and error. For *developing*, mathematically, the strategies given were accurate but had no key of concept, pedagogicly, some strategies were relevant to solve students' misconception and error; or mthematicaly, the strategies given were accurate and had some keys of concept and idea, pedagogicly, the strategies given could not entirely solve students' misconception and error. Level of *Naive* had strategies which were not accurate or did not give mathematical strategy at all and did not give strategy in solving students' misconception. Result of the study shows that content knowledge affects on pedagogic knowledge.

Educators of teachers should understand and know not only the beliefs of PSTs have, but also how they get it, because the way teacher get belief affects on the belief they have. By knowing this, educators can eventually identify the changes to be done (Philipp, 2007). Considering the weakness of teacher and PSTs in Arithmetics and Geometry material, that is the weaknesses on CK (Couto & Vale, 2014; Hinton, et al. 2014) and weakness on PCK (Livy & Vale, 2011), according to Thompson (Philipp, 2007) it is important in a study to consider the relation of beliefs and knowledge togetherly.

The grading of MKT and Mathematical Beliefs (MB) will be in the form of comparison of MKT category and MB characteristic. The designed MKT, is adjusted with the result of study that PSTs who do not master content and can not identify concept as the center of topic they can not identify the correlation of content (connection), make representation and are weak on pedagogic knowledge (Ma, 1999; Lee & Yim, 2014). Besides, according to Moursund (2005) mathematics maturity is not basic knowledge of specific field of mathematics content, but improvement of mathematics content. Therefore the grading done position content mastery as the basic of MKT mastery continued by MPCK mastery. The study on the correlation between MKT and MB refers to Novikasari, Suryadi, and Darhim (2015).

Table 2 Leveling of Mathematical Beliefs and MKT

Mathematical Knowledge for Teaching (MKT)				Levels of Mathematical Beliefs and MKT	Levels of Mathematical Belief (Ernest, 1989; Mosvold&Fauskanger,2013)
Mathematical Content Knowledge (Ball et al, 2008 & Tatto et al, 2008)	Mathematics Pedagogical Content Knowledge (Ball et al, 2008&Tatto et al, 2008)	Knowledge Quarter (Rowland & Turner, 2007)	Somayajulu (2012)		
The ability to count procedural		*Foundation*	*Naïve*	0 Not Developing	Instrumentalist
The abilities to memorize & to define				1 Not Yet Developing	
The ability to represent mathematical ideas	The ability to select examples or representations to explain	*Transformation*	Developing	2 Quite Developing	Platonist
The ability to make connection of mathematical ideas	The ability to understand mathematical structure and topic	*Connection*		3 Developing	
The ability to make connection of students' ideas and mathematical ideas	The ability to anticipate students' unexpected responses	*Contingency*	Mature	4 Mature	Problem Solving

The PSTs' solutions showing their knowledge of mathematical content, where procedural counting ability is separated from the ability to memorize and to define (Hinton et al, 2014). Level 0 and level 1 show that PSTs do not master pedagogical knowledge because they have instrumentalist belief with an inclination to prioritize more the ability to memorize formulas than concept understanding. Level 2 and 3 have mastered the content and are in the development stage of pedagogical content knowledge. These levels believe that PSTs are more important to understand the concept than to memorize it. Level 4 believes that mathematics presented through an exploration of questions independently can develop students' mathematical knowledge corresponding with their ability.

Problem-Based Learning

PBL approach describes learner-centered principle, among others showing the students how to represent developed knowledge; giving time to students to reflect the learning process; giving choice and control to the students in collaborative context; and appreciating individual perspective with the plan it has (Pierce & Lange, 2001). The principle, according to Delisle (1997), makes the students try to understand the correlation between the studied material and the reality. The learning conducted using PBL is in line with the theory of Dewey (1997), that giving relevant problem situation and the existence of group work as stimulus for interaction in lecture can develop students' knowledge and skill to become teachers in the future.

Problem-based learning, according to Barrows and Tamblyn (1980), is "*the learning that results from the process of working toward the understanding or resolution of a problem*" (p.18). The problem given has the authentic and ill-structured characteristics. The characteristics, according to Torp and Sage (2007), support students to learn actively, support knowledge construction, and naturally combine learning and real world. The activities of PBL cover discussion, reflection, research, project, and presentation. The role of lecturer are as speaker, facilitator, trainer, and evaluator in the form of guidance, teaching, and resource to help students gain knowledge and skill of problem solving. The evaluation is authentic, competence-based, and done continuously (Levin, Dean, & Pierce. 2001).

The development of PBL has been done in many universities, either in medical or education. The model of PBL, based on the objective, contains among others content competence model and professional action model (Matusov, Julien, & Whitson, 2001; Savin-Baden, 2003). The first is a model expecting teacher candidates to learn content with having the competence to apply knowledge in context solving and enabling them to rule the problem. The later model is aimed at making the candidates "know-how." Learning enables teacher candidates to do and become competent in practice. In this case, the candidates learn how to solve problem and be competent to apply ability in certain scenario and other situation. The stressing is to result effective skill based on the right knowledge. Being competent to practice does not only result in right knowledge and skill but also attitude known by the facilitators that is suitable for profession life (Matusov et al., 2001). The steps of PBL refer to Torp and Sage (2002), namely: presenting problem, identifying problem, defining problem statement, gaining information and sharing, deciding solution and checking the truth, presenting the solution, and reflex the problem. The steps of PBL in this study combined step 4 and 5, because from the source of information and sharing steps, PSTs can decide solution chosen to solve the problem.

Research Method

This is a case study research which examined two groups of PSTs who had joined problem-based learning and traditional learning. The choosing of PSTs sample was based on the result of MCK and MPCK test by grouping the PSTs into high, medium and low groups. Referring to Cohen et al. (2007), in case study, cause and result can be verified because result is examined in real context. Context has major role to present cause and result. The context was shown to know the characteristics of PSTs with mathematics teaching knowledge level covering MCK and MPCK viewed from the mathematical beliefs they had. The formulation process of PSTs profile based on MCK and MPCK, and mathematical beliefs stopped when data had come to saturation.

The instruments used in this study were test and interview. MCK and MPCK test were developed from Ma (1999) and Cheang et al. (2007) then consulted to experts and tried on teacher candidates students. The valid tests were given in the beginning and end of learning. The progress of MCK and MPCK tests were then divided into three categories, namely high, medium and low. Interviews were done for data triangulation. In addition to MCK and MPCK test results, to determine mathematical beliefs, as refers to the opinion of Schmidt and Kennedy (1990) that someone's belief can affect not only on pedagogical choice but also content choice, so interviews were also done. According to Anney (2014) data credibility of qualitative research can be obtained with data triangulation using different research instrument. Interviews were based on MCK and MPCK test results and their category of mathematical beliefs from Mosvold and Fauskanger (2013).

Results

Identification process of MCK and MPCK test in two classes with PBL which was 'student centered' and traditional learning which was 'teacher centered' were done to know the characteristic of MCK and MPCK and MB formed from the learnings. The following is description of answers given by the PSTs in the beginning of joinning PBL and traditional learning. Give the meaning of $\frac{3}{4} \times \frac{4}{7}$!

Teacher candidate : "Mam, how does it mean?"

Researcher : "You are asked to explain the meaning of fraction multiplication $\frac{3}{4} \times \frac{4}{7}$, you may use the example in our daily life."

Teacher candidate : "Should we use picture Mam..? I used to use direct way Mam. From the past time I was taught that way, quantifier multiplied by quantifier and denominator multiplied by denominator."

Researcher : "Is it possible to use other way to get the final result, beside that way?"

Teacher candidate : "Huh, I don't know Mam. Other friends are also taught the same way. It is faster Mam, isn't it??.."

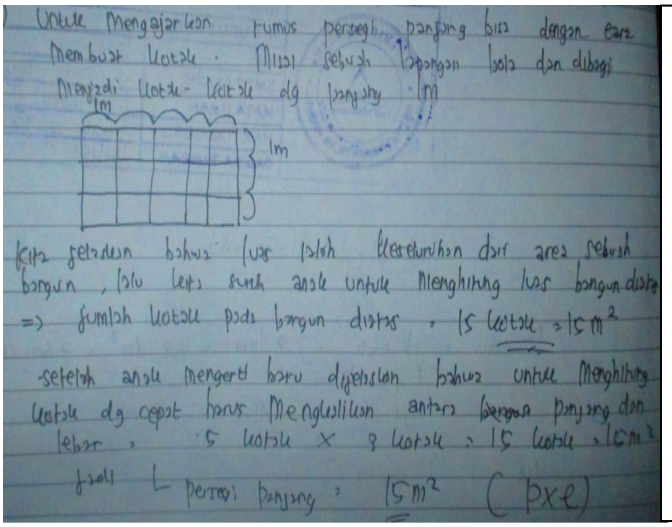
Researcher : "Is there any example of the multiplication in our life?"

Teacher candidate : "Mmm.. yes Mam, but just use the direct way Mam, as the solution.."

Most of PSTs who would be involved in this research had such view. Then learning in two different classes were done to know the change of PSTs. Sample was taken until the researcher obtained the characteristics saturation on MKT and MB they had. The following are the results obtained based on interview about :

Imagine you are about to teach a material about periphery and space of rectangular form. How can you teach it to students who will get the material for the first time?

The example of question above was given in interview. Subject 1 was identified having high category of MCK and MPCK test. The answer given is as follows.

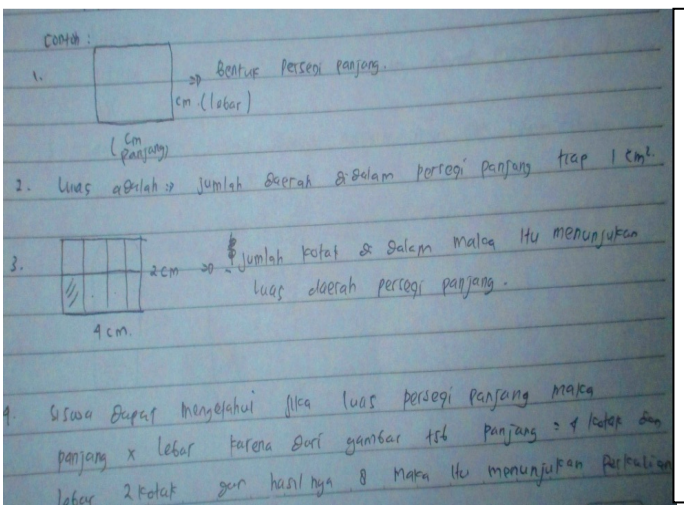


To teach the formula of rectangle we can draw a rectangle, for examlple, it is a football field. We than divide it into small rectangles with the size of 1 meter each.

We explain that space is the total area of a form. Then we ask the children to calculate the space of the above form ➔ the sum of rectangles in the above form = 15 rectangles = 15 m^2.

After children understand, then we explain that to count rectangle space quickly we must multiply length with width = 15 rectangles x 3 rectangles = 15 rectangles = 15 m^2.

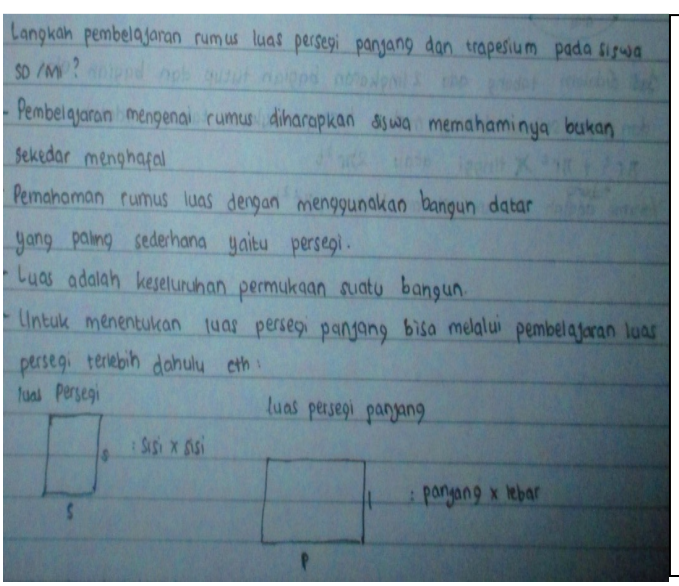
Figure 1 Result of Test-Based Interview Subject 1



Example :

1. Draw a square form, length 1 cm, width 1 cm.
2. Space is the total of area in the rectangle per 1 cm^2.
3. The amount of small squares inside the rectangle shows the space of the rectangle.
4. Students can know that the space of rectangle is length x width. Because on the picture length = 4 squares and width = 2 squares, so the result is 8. It shows a multiplication.

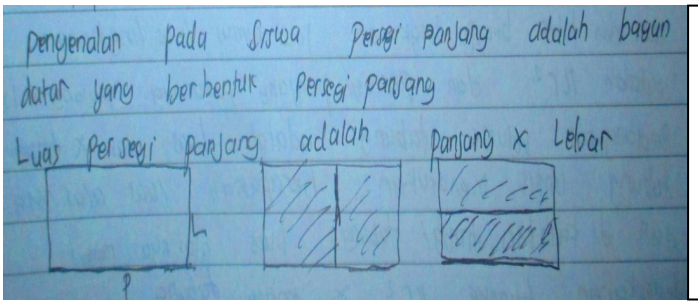
Figure 2 Result Test-Based Interview Subject 5



The steps of learning about the formula of space of rectangle and trapezoid for SD/MI students?

- After learning about the formula, students are expected to understand not only memorize. Comprehension on formula of space using the simplest form that is rectangle.
- Space is the total surface area of a form
- To determine the space of rectangle can be done through a learning on space of square first. Example :
  Square space : side x side;
  rectangle space : lenght x width

Figure 3 Test-Based Interview Subject 9



Introduce to the students, that rectangle is flat form with the shape of rectangle.

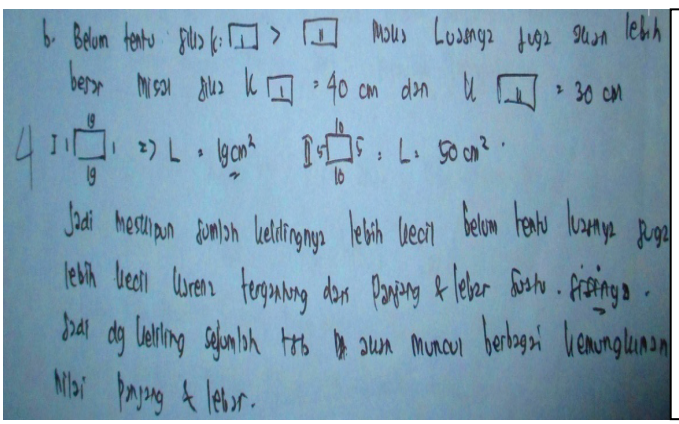
The space of rectangle is lenght x width

Figure 4 Test-Based Interview Subject 6

Subject 1 and subject 5 had similarity in solving the above problem. Both samples were categorized identical test result, that was MCK and MPCK in high category. Researcher then differentiated the two samples by giving follow up questions :

There is a student who asks a question : Pretending there are two rectangles. If the periphery of the first retangle is bigger than the second one, is the space of the first rectangle exactly bigger than the second one?

Subject 1 was able to give answer reason which was complete and appropriate for the question. Subject 5 answered with incomplete reason, as the followings :

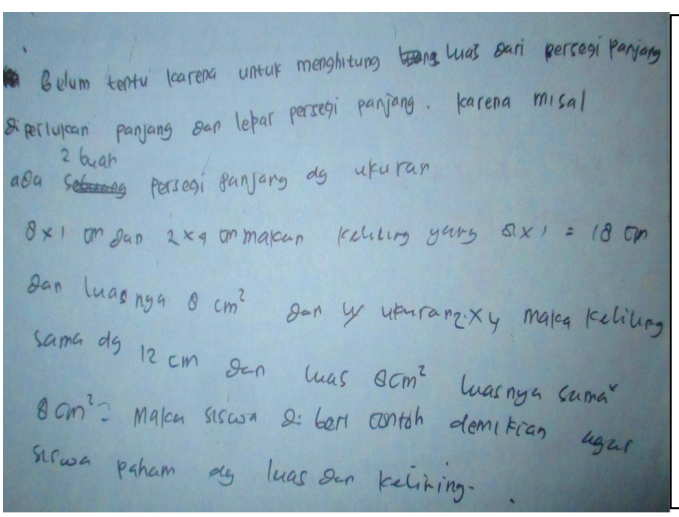


It is not exactly if periphery of rectangle I is bigger than rectangle II, then the space is also bigger. For example, if periphery of rectangle I is 40cm and rectangle II is 30cm.

I : space = 19cm², II : space = 50cm².

So, eventhogh the pheripery is smaller, it is not exactly the space is bigger. It depends on the lenght and width and the sides. With the periphery above, various probabilities of lenght and width value will emerge.

Figure 5 Showing that Subject 1 was able to anticipate students' respond



Not exactly, because to calculate space of rectangle, lenght and width are needed.

For example, there are 2 rectangles with the sizes of 8 x 1 cm and 2 x 4 cm. The periphery of the 8 x 1 size = 18 cm, and the space = 8cm². While for the 2 x 4 size, the periphery is 12 cm, and the space is 8 cm². The space are the same, 8 cm².

The students are given the example to make them understand about space and periphery.

Figure 6 Showing that Subject 5 was incomplete in anticipating students' respond

The aspect which differenciated Subject 1 and Subject 5 despite their sameness in category of MCK and MPCK test result was ability to anticipate students' respond. Further, the work results of the four subjects above were confirmed with the question, *Which is more important, memorizing formula or understanding concept first?* The following are answer descriptions of the teacher candidates.

Table 2 Interview Results

PSTs	Category of MCK and MPCK Result	Answer	Identification of Mathematical Beliefs
Subject 1	High MCK and MPCK	*In my opinion in mathematics learning, it is important for students to understand concept first as a basic for creation then they can automatically mastter/memorize formula*	Constructivist
Subject 5	High MCK and MPCK	*In my opinion in mathematics learning, it is important for students to understand concept first then they can memorize formula*	Platonist
Subject 9	High MCK and medium MPCK	*It is more important to memorize formula then students can use the formula to do the question*	Instrumentalist
Subject 6	Low MCK and MPCK	*Formula is more important beause students can directly master mathematics content matematika quickly.*	Instrumentalist

The next examination was then carried out on other samples. The summary of all profiles of sample are presented in the following table, which shows the tendency of the four types of mathematics belief.

Table 3 Analysis Result of PSTs' Mathematical Beliefs Profile

PSTs	Mathematical Beliefs	Description
Subject 1, Subject 2	Konstructivist	- PSTs master all aspects of MCK and MPCK - Belief that mathematics is beneficial for daily life, and are able to give example. - Develop under PBL environment so that they know the mathematical problems of students and teachers - This type theoritically develop with creation, this is in line with finding that the teacher candidates have characteristic of creative, meaning that they are able to give mathematical ideas to respond students' thinking appropriately - PSTs study in class actively exploring problems - There is significant progress of MCK and MPCK - Teaching plan is designed with orientation on comprehension
Subject 3, Subject 4, Subject 5	Platonist	- PSTs do not master the aspect of anticipating students' respond by making connection of students' idea and mathematical idea on MPCK aspect - Very strong tendency to master MCK - Believe that mathematics is beneficial for daily life - Assumed to be able to develop through experience which make them sensitive in making students' mathematics responds - Creativeness is under construktivistic type - PSTs are active in exploring problems - Teaching Plan is designed with orientation on comprehension
Subject 9, Subject 10, Subject 11, Subject 12	Last Instrumentalist	- PSTs do not master aspects of MPCK - PSTs master the aspect of MCK quite well - Belive that mathematics is beneficial for daily life but can not give example - Teaching plan is designed with orientation on formula - Active in exploring problems
Subject 6, Subject 7, Subject 8	Beginning Instrumentalist	- PSTs do not master MCK and MPCK - Believe that mathematics is beneficial but can not give example - Teaching plan is designed with orientation on formula - Passive in exploring problems

The above sample were randomized between PBL and ordinary learning. Sample originated from PBL class among others were Subject 1, Subject 2, Subject 3, Subject 9, and Subject 6. Besides, samples were obtained from PSTs joining ordinary learning. The result above shows that contructivist mathematical belief was obtained only in PBL class. Constructivist belief did not only have progress on high category of MCK and

MPCK, but Subject 1 and Subject 2 were also able to make creation by giving complete answer on students' respond probability. It can be estimated that when becoming teachers, Subject 1 and Subject 2 can develop quickly becoming mature teachers, who are competent in school mathematics field.

Discussion

Mathematical beliefs of PSTs grow years as long as their interaction with mathematics since little children to adult, either in education or in real life. But it is not impossible that the experiences shaped years can be changed in teacher education as the opinion of Luft and Rehrig (2007) that experiences obtained by PSTs during their joining in teacher education program, will influence their beliefs when they become teachers.

The grading developed from assumption of correlation between MKT and MB in Novikasari, et al. (2015) can still be invesigated with the result of research findings. For example, based on finding result in Table 3, PSTs with instrumentalist mathematical beliefs had possibility of low, medium and high category of MCK. The differentiating aspect was the result of MPCK test which were on medium and low category. PSTs with platonist MB were only found having high and medium category of MCK test result, and having medium and hight category of MPCK test results. PSTs with constructivist MB were consistent of having progress of high category of MCK and MPCK.

The next question is, isn't it possible for instrumentalist MB to have high MCK and MPCK progress? When investigated deeper, PSTs with instrumentalist MB should not be possible to have high MCK and MPCK progress because contently and pedagogicly they tended to focus on memorizing and giving of formula. This can be explained from the finding of interview result, that instrumentalist PSTs used calculating way as guidance to make picture representation. That is why there were same PSTs who directly give final picture representation without being able to explain the idea.

Beliefs which is an individual costruct, according to Philipp (2007), is proved with the owned knowledge, because individual with certain belief and proved with the knowledge he has will have more ability to give argument of what he believes. If belief and knowledge of someone is differrent, the owned knowledge is not able to give strong argument, such as instrumentalist PSTs who found difficulty in giving explanation of the representation given.

PSTs of instrumentalist MB with various progress of MCK and MPCK were found. For example, PSTs Subject 9 who had medium MCK and MPCK progress. PSTs Subject 10 had medium MCK and high MPCK progress. High MCK and high MPCK progress were owned by Subject 11.

The next question appears on Subject 12 which had high MCK and MPCK progress, why the PSTs had instrumentalist belief? Investigation was done on pretests results which showed quite good result on MCK score of 8 from maximum score of 16 and MPCK score of 5 from maximum score of 10 and MCK postest score of 15 from maximum of 19 and MPCK score of 31 from maximum of 38. The case occured on Subject 12 is possibly in line with the identification of Philipp (2007), that belief is proved with the owned knowledge so that it is necessary to conduct further investigation on the owned MB. The final result showed that different progress did not change someone's belief. The same final result could be caused by the process of training in PBL.

The PSTs with instrumentalist MB were also found in the two research classes. Petrou and Goulding (2011) stated that the teacher type who believes that mathematics consists of a number of rules and routine

problems they will require their students to memorize formula first. Such type of teachers, for example Subject 10, Subject 11, and Subject 12 in ordinary learning class, Subject 9 and Subject 6 in PBL class. They had motivation to solve problems but not to be showed off in front of class. PSTs with instrumentalist MB found difficulty in comprehending mathematical idea and tended to solve problem using abstract way. As stated by Ball (1990), PSTs with knowledge that is based on memory will experience difficulty in yielding representation of idea or difficulty in giving exact reasonable explanation of their calculation. In other word, PSTs have weaknesses in connecting mathematical concepts.

PSTs with platonist MB were only found having medium and high category of MCK progress, and having low, medium and high categories of MPCK progress. PSTs with platonist MB and MCK progress of minimally medium category had been included in grading criteria of Table X. For example PSTs Subject 5 had medium MCK and MPCK progress. PSTs Subject 4 had medium category of MCK and high category of MPCK. PSTs Subject 3 had high MCK progress and medium MPCK. Subject 5 in ordinary learning class tended to be active and had the highest mathematics knowledge in their class. Although Subject 5 was in ordinary learning class with presentation of speeches on problems like those in PBL1 dan PBL2 classes, He often showed different thinking in solving problem. The development oblstacle was identified by Brousseau (1997) as *ontogenic obstacle*. This is among others caused by learning process which is not suitable with the capacity of PSTs, which can be maximum but learning process does not cause them to be advanced. The occuring learning was not effective because it was too technical or may be too simple. Subject 5, like Subject 3 and Subject 4 had high mathematical knowledge in class. In the beginning of the interview researcher expected they had constructivist MB, but they were incomplete in giving reason of correlation between space and periphery.

PSTs with instrumentalist MB were found having various category of MCK and MPCK progress. It was almost indifference the result of MCK and MPCK progress of PSTs of instrumentalist and platonist categories. The tendency of instrumentalist in learning existed on teacher candidates who were weak in MCK and MPCK. But there were also teacher candidates with good MCK and MPCK but still believed that mathematics is a collection of formula. Therefore, the ideal learning and teaching way in their opinion is by memorizing and mastering formula. The following is example of test answer of teacher candidates with instrumentalistics MB.

PSTs with constructivist MB were found having high MCK and MPCK progress. This criteria were owned by two persons namely Subject 1 and Subject 2. The teacher candidates had pretest and postest scores which were categorized high in their class. Before and after PBL had significant progress. The background of PST Subject1 who was from Vocational High School of computer department, based on the result of inverview, showed that he indeed thought from the beginning that mathematics is an advantageous science. But in the process of PBL he once gave a comment that teaching mathematics is faster using abstract way. PBL process had changed his view that teaching should be done to each individual based on their understanding, meaning that he had constructivist tendency. Like subject 1, PST subject 2 had constructivist tendency in PBL. The strength of PSTs with constructivist MB was in the aspect of anticipating students' thinking. On this aspect it was known there were only some PSTs were able to give feed back to students' thinking. According to Ball, et al. (2008) on this aspect, PSTs who can determine the best way in bulding students' thinking mathematics or how to correct studets' error are needed. In teachers' pedagogic competence, the aspect is in line with the competence of students' characeristic mastery and facilitating students' development.

PSTs in ordinary learning class had instrumentalist and platonist MB. There was almost no difference of MCK and MPCK progress between the two MB. Candidates of platonist MB tended to have high category score since pretest, and increased on the score of postest. The progress of istrumentalist MB was only improvement of knowledge without being followed with change of MB.

Based on analysis on the results of MB and progress of MCK and MPCK above, it was obtained that grading of MB, MCK, and MPCK (Novikasari, et al., 2015) was valid on PSTs of all types of MB. But for platonist type, level 2 and level 3 could not be differentiated yet. MCK and MPCK progress occuring on instrumentalist MB was a form of MCK and MPCK 'knowledge' which was trainned during joining PBL and ordinary learning, because on that level, PSTs still found difficulty in making representation and connection of mathematical ideas. As stated by Cooley (2002), most learners of any age still find difficulty in making deep interpreting on what they learn.

The obvious difference of PSTs with constructivist and platonist beliefs was identified by Fandiño (2007) as dydactic transposition, that is abiliy to change "knowledge" into "taught knowledge". In his opinion, teacher candidates who are able to make creativeness are needed in this aspect. The creativeness of PSTs on this aspect had not developed maximally in the three research classes.

Conclusion

Constructivist mathematical belief started to grow in PBL class. The belief was shown by PSTs in test and questionnaire-based interview by explaining the way to teach material of space and periphery. PSTs were then able to make creation of problem on some mathematics topics. PSTs with this mathematical belief that mathematics is beneficial for daily life. In ordinary learning class, no PSTs of contructivist mathematical beliefs was found. This was identified by Brousseau (1997) as *ontogenic obstacle*. The cause may come from inaproppriate learning process, which cause PSTs have no progress.

In the two research classes, PSTs with platonist and instrumentalist MB were found. PSTs with platonist MB tended to be able to explain the way to teach material of space and periphery, but not complete enough in making creation of problem on some matematics topics. PSTs of instrumentalist MB were divided into two types, namely beginning instrumentalist MB, where PSTs were very weak in knowledge to explain the required concept, so that PSTs tended to think mathematics as difficult lesson. PSTs with late instrumentalist MB showed ability to explain material of space and periphery directly on formula. PSTs of this type did not give explanation of the process to get the formula.

References

Anney, V., N. (2014). Ensuring the Quality of the Findings of Qualitatuve Research: Looking at Trustworthiness Criteria. *Journal of Emerging Trends in Educational Research and Policy Studies*, 5(2), pp. 272-281.

Ashun, M.A., & Reinink. (2009). Trickle Down Mathematics: Adult Pre-Service Elementary Teachers Gain Confidence in Mathematics – Enough to Pass it Along? *Adults Learning Mathematics International Journal*, 4(1), pp. 32-40.

Ball, D. (1990). The Mathematical Understandings that Prospective Teachers bring to Teacher Education. *Elementary School Journal*, 90, pp. 449-466.

Ball, D. (2000). Bridging Practices: Intertwining Content and Pedagogy in Teaching and Learning to Teach. *Journal of Teacher Education*, 51 (3), pp. 241-247.

Ball, D., Hill, H. C., & Bass, H. (2005). Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide? *Journal of the American Federation of Teachers*, pp. 14-22.

Ball, D., Thames, M., & Phelps, G. (2008). Content Knowledge for Teaching What Makes It Special? *Journal of Teacher Education*, 59 (5), pp. 389-407.

Barrows, H., & Tamblyn, R. (1980). *Problem-Based Learning An Approach to Medical Education*. New York: Springer Publishing Company.

Baswedan, A.R. (2014). Gawat Darurat Pendidikan di Indonesia. *Paper is Based on a Speech in Ministry Gathering with the Head of Departement*. Jakarta, December 1, 2014.

Brousseau, G. (1997). *Theory of Didactical Situations in Mathematics*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Cheang W. K., Yeo K. J., Chan C. , Lim-Teo S. K., Chua K. G., & Ng L. E. (2007). Development of Mathematics Pedagogical Content Knowledge in Student Teachers. *The Mathematics Educator*, 10 (2), pp. 27-54.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education*, sixth edition. USA: Taylor & Francis Group.

Cooley, L. (2002). Writing in Calculus and Reflective Abstraction. *Journal of Mathematical Behaviour*, 21, pp. 255-282.

Delisle, R. (1997). *How to Use Problem-Based Learning in The Classroom*. USA: Association for Supervision and Curriculum Development (ASCD).

Dewey, J. (1997). *Experience and Education*. New York: A Touchstone Book.

Ernest. (1989). Impact of Beliefs on the Teaching of Mathematics', in P. Ernest, Ed. *Mathematics Teaching*: *The State of the Art*, London: Falmer Press, pp. 249-254.

Fandiño, P. M. I. (2007). Fractions: conceptual and didactic aspects. *Acta Didactica Universitatis Comenianae*, 7, pp. 23-45.

Goldin, G. (2002). Affect, Meta-Affext, and Mathematical Belief Structure. In Leder, G., Pehkonen, E., Törner, G (Eds.). *Beliefs: A Hidden Variable in Mathematics Education?* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Hill, H.C,, Ball, D.L., & Schilling, S.G. (2008). Unpacking Pedagogical Content Knowledge: Concetualizing and Measuring Teachers' Topic-Spesific Knowledge of Students. *Journal for Research in Mathematics Education*, 39 (4), pp. 372-400.

Hill, H.C., Rowan, B., & Ball, D. (2005). Effects of Teachers' Mathematical Knowledge for Teaching on Student Achievement. *American Educational Research Journal*, 42 (2), pp. 371–406.

Kajander, A. (2007). Unpacking Mathematics for Teaching: A Study of Preservice Elementary Teachers' Evolving Mathematical Understandings and Beliefs. *Journal of Teaching and Learning*, 5(1), pp. 33-54.

Kennedy, M.M. (1999). The Role of Preservice Teacher Education. In Darling-Hammond, L. & Sykes, G (Eds.). *Teaching as the Learning Profession: Handbook of Teaching and Policy*, (pp. 54-86) San Fransisco: Jossey Bass.

Kiely, R., Sandmann L., & Truluck, J. (2004). Adult learning and the pursuit of adult degrees. *New Directions for Adult and Continuing Education*, 103, pp. 17-30.

Lee, H., & Yim, J. (2014). Pursuing Coherence among Proportionality, Linearity, and Similarity: Two Pathways from Pre-service Teachers' Geometric Representations. *The Mathematics Enthusiast*, 11 (3), pp. 541-554.

Levin, B. (2001). *Energizing Teacher Education and Professional Development with Problem-Based Learning*. Virginia: Association for Supervision and Curriculum Development.

Levin, B., Dean, C., & Pierce, J. (2001). In Barbara Levin (Ed), *Energizing Teacher Education and Professional Development with Problem-Based Learning*. USA: ASCD.

Luft, J., & Roehirg, G. (2007). Capturing Science Teachers' Epistemological Beliefs: The Development of the Teacher Beliefs Interview. *Electronic Journal of Science Education*, 11 (2), pp. 38-63.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, N.J: Lawrence Erlbaum Associates.

Matusov, E., Julien, J., & Whitson. J.A. (2001). PBL in Preservice Teacher Education. In Duch, J.B., Groh, S.E., Allen, D.E. (Eds), *The Power of Problem-based Learning*. Virginia: Stylus Publishing.

Moursund, D. (2005). *Improving Math Education in Elementary Schools: A Short Book for Teachers*. Retrieved September 10, 2012 from http://darkwing.uoregon.edu/~moursund/Math/El Math Book.pdf.

McLeod, D. (1992). Research on Affect in Mathematics Education: a Reconceptualization. In D. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning*. New York: MacMillan Publishing Company.

McLeod, R., & Newmarch, B. (2006). *Maths4Life*: Fractions. London: NRDC.

Mosvold, R., & Fauskanger, J. (2013). Teachers' Beliefs about Mathematical Knowledge for Teaching Definitions. *International Electronic Journal of Mathematics Education*, 8 (2), pp. 43-61.

Novikasari, I., Suryadi, D., & Darhim (2015). Developing a Leveling Framework of Mathematical Beliefs and Mathematical Knowledge for Teaching of Indonesian Pre-Service Teachers. *Educational Research and Review*, 10 (13), pp. 1839-1845.

Oughton, H. (2009). A willing suspension of disbelief? 'Contexts' and recontextualisation in adult numeracy classrooms. *Adults Learning Mathematics International Journal*, 4 (1), pp. 16-31.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 257-315). United States: Information Age Publishing.

Pierce, W., & Lange, G. (2001). Providing Structure for Analyzing Authentic Problems. In Barbara Levin (Ed), *Energizing Teacher Education and Professional Development with Problem-Based Learning*. Virginia: ASCD

Powell, A. , & Hanna, E. (2006). Understanding Teachers' Mathematics Knowledge for Teaching: A Theoretical and Methodological Approach. *Proceedings 30th Conference of the International Group for the Psychology of Mathematics Education*, 4, pp. 369-376.

Rowland, T., & Turner, F. (2007). Developing and Using the 'Knowledge Quarter': A Framework for the Observation of mathematics Teaching. *The Mathematics Educator*, 10 (1), pp. 107-123.

Savin-Baden, M. (2003). *Facilitating Problem – based Learning*. USA : SRHE & Open University Press.

Schmidt, W., Burroughs, N., & Cogan, L. (2013). *World Class Standards for Preparing teachers of Mathematics.* Michigan State University: Center for the Study of Curriculum & the Education Policy Center.

Schmidt, W., & Kennedy, M. (1990). *Teachers' and Teacher Candidates' Beliefs About Subject Matter and about Teaching Responsibilities*. Michigan: The National Center for Research on Teacher Education.

Shulman, Lee, S. (1987). Knowledge and Teaching Foundations of the New Reform. *Harvard Educational Review*, Vol. 57, No.1, pp.1-21.

Somayajulu, R. B. (2012). *Building Pre-Service Teacher's Mathematical Knowledge for Teaching of High School Geometry*. Dissertation: The Ohio State University.

Tatto, M. T., Schwille, J., Senk, S., Ingvarson, L., Peck, R., & Rowley, G. (2008). *Teacher Education and Development Study in Mathematics* (TEDS-M): Policy, practice, and readiness to teach primary and secondary mathematics. Conceptual framework. East Lansing, MI: Teacher Education and Development International Study Center, College of Education, Michigan State University.

Torp, L., & Sage, S. (2002). *Problem as Possibilities: Problem-based Learning for K-12 Education*. Virginia: Association for Supervisor and Curriculum Development.

Törner, G., & Pehkonen, E. (1999). *Teachers' Beliefs on Mathematics Teaching– comparing different self-estimation methods a case study*. Retrieved February 20, 2014 from http://www.uni-duisburg.de/FB11/PROJECTS/MAVI.html.

Welder, R., & Simonsen, L. (2011). Elementary teachers' mathematics knowledge for teaching prerequisite algebra concepts. *IUMPST: The Journal*. Vol 1, January, 2011.

Widjaja, W., & Stacey, K. (2009). Growth of Pre-service Teachers' Knowledge and Teaching Ideas About Decimals and Fractions: The Case of Vivi. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (Vol. 2). Palmerston North, NZ: MERGA.

Appendix

Interview

1. If you are in a situation to teach about the space of rectangle to students who will get the material for the first time, how can you explain the concept of space of rectangle to the students?
2. Pretending there are two rectangles. The periphery of the first retangle is bigger than the second one, is the space of the first rectangle exactly bigger than the second one?
3. When you teach later, which is more important for students, memorizing formula or understanding concept? why?
4. In your opinion, which is more difficult, mathematics material in elementary school teacher training or in school? why?
5. In your opinion, are the last six meetings of learning exciting? why?

Title: Design of a Solid Waste Compactor

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ABSTRACT

Many Developing Countries are still struggling with solid waste collection and management and Ghana is no exception. It is estimated that between one-third and half of the waste generated in most cities in low and middle-income countries respectively are not collected. Following the unrelenting urbanization and unimpressive performance of the public sector in the provision of infrastructure in many cities in low-come countries as results of personnel and logistics constraints, the search for alternative strategies for urban solid waste management service became inevitable. This study design a waste compactor used for reducing the volumes of the waste generated in both domestic and residential settings, and thereby reduces the volumes of waste to be collected for disposal to help clear our streets of filth.

Keywords: compactor, volumes, reduction, waste, disposal

1.0 Introduction

Globally, management of solid waste present huge challenges to waste management practitioners. These challenges are often felt more in the developing countries, though 20-50% of the municipalities budget are spent on solid waste management yet about 50% of their population is not served (World Bank, 2009). Solid waste collection efficiency and coverage within the urban spatial structure of developing countries has been a difficult task.

In order to improve solid waste collection in Ghana, solid waste collection services were outsourced to the private sector on contract basis. The waste collection services are either by door-to –door in the high/middle income dwellings or through the communal system in the low-income areas where public containers are used for solid waste collection (Oduro-Appiah and Aggrey, 2013).

All these modes of collection are characterized with:

- Irregular frequency and a fairly precise schedule for optimal efficiency and convenience,
- Lack of sufficient number, inappropriate types and sizes of storage containers at collection points, and
- Reliance on the conventional western methods that depends on motor vehicle and crews, which is not sustainable due to lack of proper maintenance culture, ill-motivated workforce and the lack of political commitment in emerging economy countries.

Consequentially, these waste collection service providers are not able to manage and organize adequate collection and safe disposal of the solid waste within their jurisdiction.

In Ghana, Based on an estimated population of 25 million and an average daily waste generation per capita of 0.60 kg, Ghana generates annually about 5.0 million tons of solid waste. Accra, the capital, and Kumasi, the second largest city, with a combined population of about 4 million and a floating population of about 2.5 million generate over 3,000 tons of solid waste daily. It is, however, estimated that throughout the country only about 10% of solid wastes generated is properly disposed of (Mensah and Larbi, 2005). In Accra, for example, only 11% of the 1.4 million residents benefit from home collection service (Songsore, 1992), while the remaining 89% dispose of their waste at community dumps, in open spaces, in water bodies, and in storm draining channels (Asomani-Boateng & Haight, 1999; Oteng-Ababio, 2010). In the Sekondi-Takoradi

Metropolitan Area, only an average of 60 percent the solid waste generated in the Metropolis was properly collected and disposed of in 2012. The limited waste collection and disposal capacity of the urban authority has worsened the cumulative deposition of solid waste in the metropolis.
These are evident in the virtually day-to-day overflow of waste, clogging of gutters by waste causing flooding and serving as conduits for the outbreak of communicable diseases like malaria, cholera ,dysentery, etc., unpleasant odour and poor community aesthetics.

The effective and efficient solid waste management system needed to keep our environment clean and hygienic could only be achieved if collection infrastructure can keep pace with the huge volumes of solid waste generated. But, this seems unachievable in the developing countries like Ghana as a result of lack of sustainable integrated solid waste management structure, lack of funding and equipments for waste management. Therefore, there is the need to either reduce the per capita waste generation by the application of the 3Rs (Reduce, Reuse and Recycle) or by the compaction of the waste to volumes that can be easily managed by the waste collection services providers. But, the source segregation of solid waste that underpins the application of the 3Rs is rarely practiced in Ghana and Africa (Oduro-Appiah and Aggrey, 2013) invariably making it difficult to implement the 3Rs. Experience also indicate that application of the 3Rs is difficult in the developing countries.

This study aims to design a novel solid waste compactor that can be used both domestically and commercially to reduce the huge volumes of solid generated to about 4:1 as a step gap solution to the insufficient basic infrastructure for solid waste collection. This will help reduce frequency of collection, reduce cost in fuel for waste collection, to help reduce the volumes of waste needed to be collected and hauled to the landfills by the waste collection service providers and finally improve the sanity of our urban environment.

METHODOLOGY

This section considers the requirements and methods that aided in the design of the artifact.

DESIGN REQUIREMENTS

These indicate the detailed statement, the expected specific and quantitative data with regard to the performance of the device.

- The dustbin should be able to withstand the compression pressure.
- The device should have a minimum of 75% efficiency.
- The dustbin should have wheels for easy movement from the container.
- The piston rod should be threaded to allow for it's up and down movement.
- The artifact would be manufactured from locally available raw materials.
- The metal bin should be able to carry a maximum weight of 37.7kg
- The volume of the bin is $0.10312m^3$
- The average input of the operator to manually turn the spindle is 70 watts.
- Density of waste = $366kg/m^3$

FUNCTIONAL REQUIREMENTS

Below are some of the things the device should do.

- The device should be able reduce waste into smaller volume.
- The device should have a compacting ratio of at least 4:1.
- The human effort should be able to operate and achieve the required compression ratio.
- The device should be able to convert circular motion to linear motion.
- The device should be firmly grounded.

THE DESIGN

Based on the above requirements the design below was arrived at

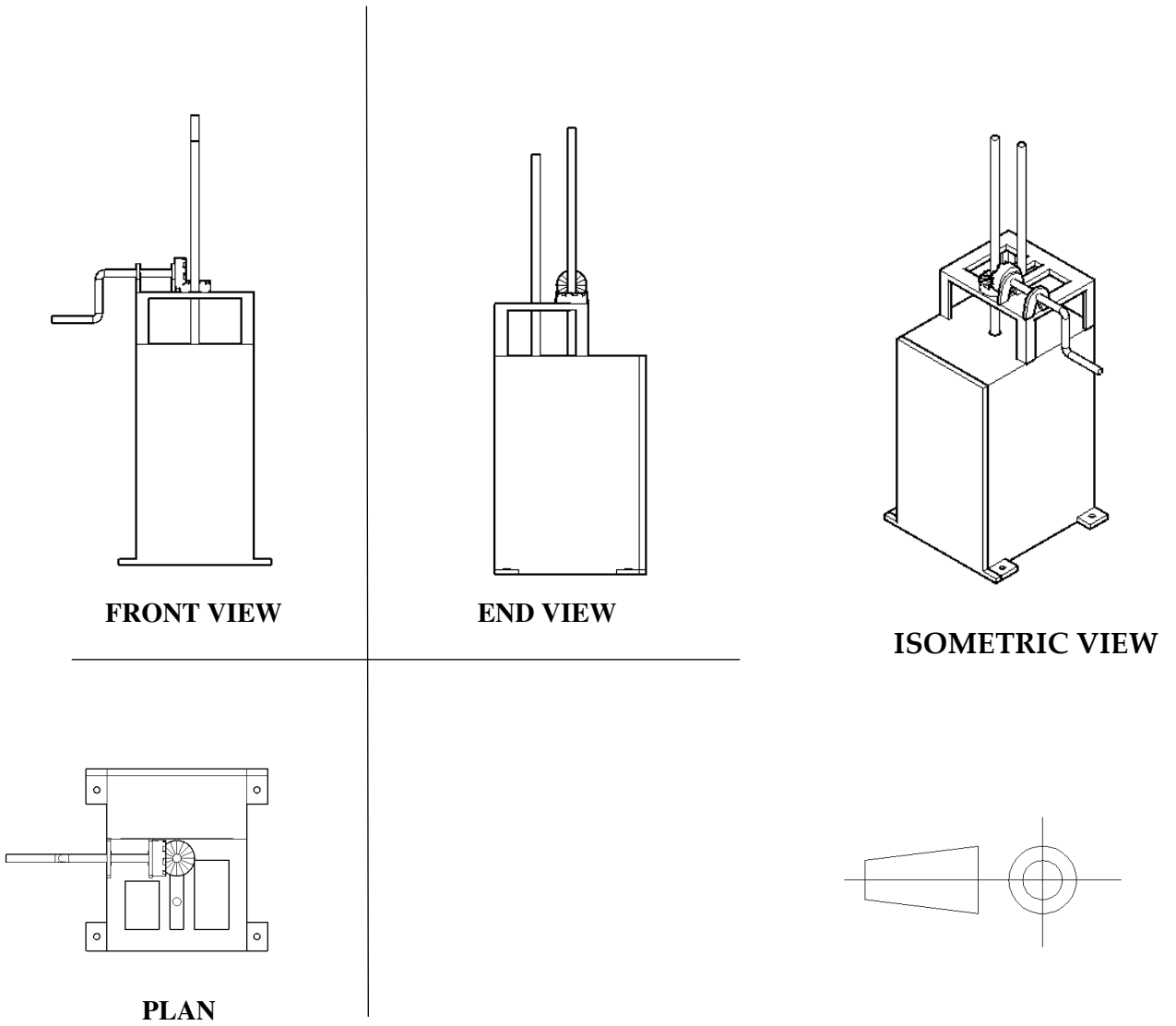

Fig.1 Pictorial and orthographic views of the waste compacting device

Found below are the exploded views and the working drawings of the design.

All dimensions are in millimeters.

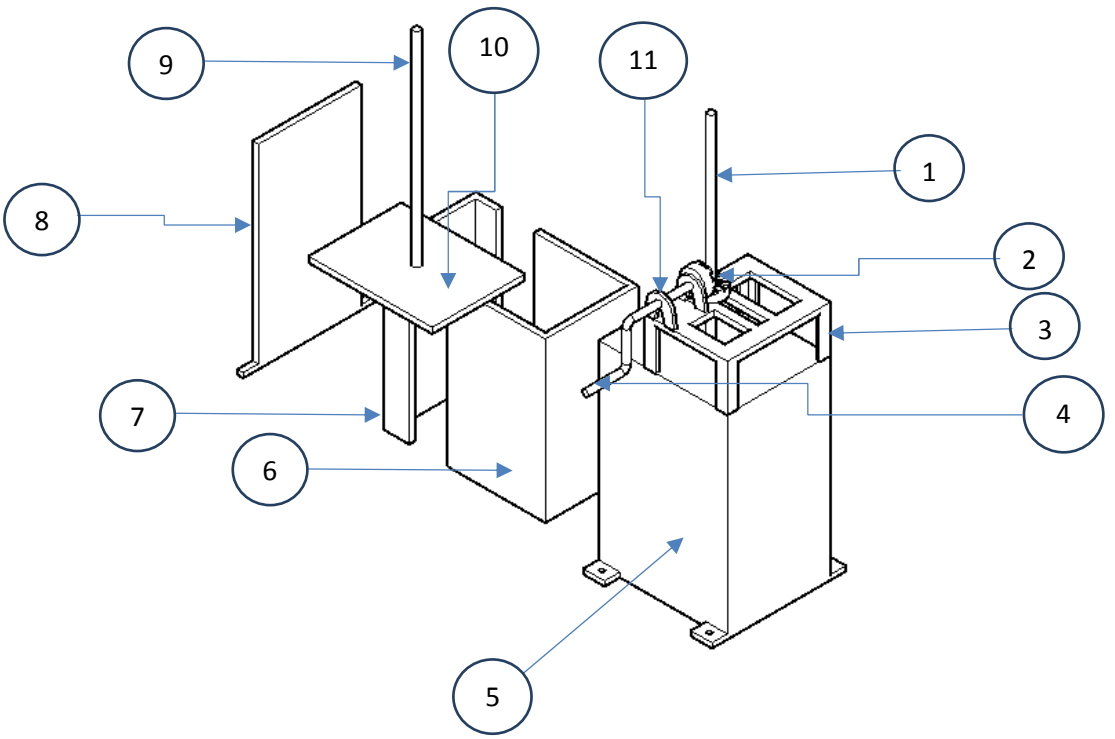

Fig.2 Exploded view of the waste compacting device

SELECTION OF MATERIALS

Materials used in the design were chosen based on their properties which allow them to perform their functions effectively.

PART LIST

PART NUMBER	PART NAME	QUANTITY	MATERIAL
1	Piston Rod	1	Mild steel
2	Bevel Gear	2	Mild steel
3	Frame	1	Mild steel
4	Spindle	1	Mild steel
5	Container	1	Stainless steel
6	Bin	1	Mild steel
7	Bin cover	1	Mild steel
8	Gate	1	Stainless steel
9	Guide Rod	1	Mild steel
10	Piston Plate	1	Stainless steel
11	Bearing	2	Mild steel

THEORY OF DESIGN AND ITS OPERATION

Torque generated from the anti-clockwise rotation action of the spindle is directed by the two plain bearings mounted on the device and the torque is efficiently transmitted to the bevel gear. The bevel gear (pinion and gear) has a velocity ratio of 3:1. Thus the speed of the pinion which is in the vertical plane is thrice the speed of gear which is in the horizontal plane. The speed reduction between the pinion and the gear helps to increase the compression force since force is inversely proportional to speed.

The gear (rotating is in the horizontal plane) is coupled to the piston by means of internal square threads in the gear and external square threads on the piston. This converts the angular motion of the gear to a linear downward stroke of the piston thereby creating the compression action on the waste in the bin by the piston plate. The piston will stop moving if the pressure built up in the bin becomes equal to the downward pressure of the piston.

To prevent the piston from wobbling, the vertical stroke of the piston must be guided. Therefore, a guide rod has been welded to the piston plate and directed by the same diameter hollow bar provided on top of the device.

To lift the piston, thus after compression has taken place; the spindle is rotated in the clockwise direction. Compression can be repeated over and over again until the pressure in the bin finally becomes equal to the downward pressure of the piston.

To determine the force the waste exerts in the bin

Volume of the container = (length × breadth × height)

Volume = $0.10312m^3$

Density of waste = $366kg/m^3$

Mass of waste = density × volume

Mass = 37.7kg

Force the waste exerts on the bin = mass × gravity

Force = 370.25N

To find the weight of piston

Volume of piston. Volume = $(\frac{\pi d^2}{4} \times h)$

Volume = $1.767\times10^{-3}m^3$

Mass of piston = density ×volume

Density of mild steel = $7850kg/m^3$

Therefore, mass = 13.87kg

Weight (force) = mass ×gravity

Weight = 136.09N

To find the weight of piston plate

Volume of the plate = (length × breadth × height)

Volume = $3.7845\times10^{-3}m^3$

Mass of piston plate = density ×volume

Density of mild steel = $7850kg/m^3$

Mass = 29.71kg

Weight (force) = mass ×gravity

Weight= 291.44N

Total force/ weight = 427.53N

Average Manual Power = 70W

Power = force × linear velocity

Linear velocity = 0.16374m/s

Angular velocity = $\frac{linear\ velocity}{pitch\ radius\ of\ gear}$

Angular velocity (gear) = 0.182rad/s

Velocity ratio (speed of the pinion is thrice the speed of gear) = 3:1 therefore,

Angular velocity of pinion = 3 × Angular velocity of gear

Angular velocity of pinion = 0.5458rad/s

To find the force generated from the spindle

Torque = $\frac{power}{angular\ velocity}$

Torque = 128.25Nm

Force = $\frac{torque}{radius}$

Force = 641.26N

Load transmitted = $\frac{torque}{pitch\ radius}$

Load transmitted = 1425N

CONCLUSION

Early studies on urban solid waste management have reported a combination factors affecting the management of solid waste in the growing cities of the developing world. In Africa, solid waste collection and disposal is reported to be the next environmental menace after water quality. The institutions mandated to ensure proper collection, transportation and safe disposal of waste is challenged logistically, thus the skips, bins and vehicles are not able to contain the huge volumes of waste generated. The waste compactor was designed and used to reduce the volumes of waste generated from the households ending up at the collection or disposal sites and simultaneously act as a storage facility.

REFERENCES

- Asomani-Boateng Raymond & Haight Murray (2004). Reusing organic solid waste in urban farming in African cities: A challenge for urban planners. Retrieved from www.idrc.ca/publication/online books)
- Boadi K.O and Kuitunen, M. (2004). Municipal Solid Waste Management in the Accra Metropolitan Area in the Environmentalist Journal. Volume 23, No.3

- Mensah Anthony & Larbi Eugene. (2005). Solid waste disposal in Ghana. Quality Assurance: Andrew Cotton (retrieved from www.waste.trend.net, on 14/06/06)
- Songsore Jacob (1992). Review of household environmental problems in Greater Accra, Ghana. Stockholm Environmental Institute (SEI), Sweden.
- Oteng-Ababio, M (2010), Missing links in Solid Waste Management in Greater Accra Metropolitan Area in Ghana. Geojournal, doi.10.1007/s10708-010-9363-90.
- Oduro-Appiah K & B. E. aggrey (2013). Determinants of source separation of municipal solid waste in developing countries: The case study of Ghana. Journal of Sustainable Development in Africa (Vol. 15 No.3 pp 47 – 60)

THE EFFECT OF SERVICES OF MICRO FINANCIAL INSTITUTIONS ON THEIR FINANCIAL PERFORMANCE: A VIEW FROM GHANA

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ABSTRACT

The rampant collapse of Microfinancial institutions in Ghana in recent times justifies investigation into the effect of the core services (micro-credit and micro-savings) on their sustainability. The study assesses the effect of the core services namely: micro-credit and micro-savings on the sustainability of Microfinancial Institutions.

The study was conducted in Ghana using unbalance panel data from a sample 16 selected Microfinancial Institutionsin the country which had reported to the Microfinance Information Exchange Market for a seven year period. The study adopted quantitative approach and used the Pooled Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) in analysing the data.

The study found that micro-credit, age, regulatory status, financial intermediation and outreach had positive and statistical significant effect on operational self-sufficiency. However, micro-savings, size, diamond rating and profit status had negative and statistical significant effects on operational self-sufficiency. The study also found that age and target market had positive but outreach had negative statistical significant effect on portfolio at risk. Both micro-credit and micro-savings have weak positive and insignificant effect on portfolio at risk.

The findings of the study have several implications for researchers, managers and Policy Makers and specific recommendations are that Managers of MFIs should manage key intervening factors like outreach, size, profit motive and adhere to regulatory requirements so as to enhance their sustainability. Also Managers should reduce cost associated with mobilizing micro savings through the use of technology and money box.

Keywords: *micro-credit; micro-savings; Operational self- sufficiency; Portfolio at risk; Sustainability*

1. INTRODUCTION

Microfinance has been generally accepted as a developmental tool (Augsburg, 2009; Ibtissem and Bouri, 2013) and widely adopted by developing economists as such. According to Simanowitz and Brody (cited in Bank of Ghana Report, 2007), micro-financing (MFs) is also a promising tool for reaching the Millennium Development Goals (MDGs) and for building global financial systems that meet the needs of the less privileged.

In Ghana the rampant collapse of MFIs of late has raised the concern of all stakeholders as itthreatened the attainment of these goals. Thus ways must be found to make these institutions sustainable. This is because it is only sustainable institution that can deliver services in sustainable ways to meet the needs of their clients and those of MDGs. The core business of MFIs is to develop methods that can enable them to extend financial services to the hitherto un-bankable.However, in Ghana,like most countries, the regulatory framework of MFIs does not allow all the various categories of MFIs to accept deposit. There is the need to research into the core services (micro- credit and micro-savings) to assess the influence they exert on their sustainability and to identify the influence each of these services individually exerts on the financial performance of MFIs.

1.1Statement of Problem:

The performance of Microfinancial institutions has been of great concern to all stakeholders of which Ghana is no exception. This is because Microfinancing hasgained reputable acceptance from all sectors as a development tool (Boateng andAdjei, 2013) and has also become part and parcel of the financial system of Ghana. The rampant collapse of MFIs in the country is therefore a great worry to all stakeholders and has attracted several national debates.The importance of having sustainable MFIs has been re-affirmed by Nyamsogoro (2010) cited by Gashayie and Singh (2015) that it is better not to have MFIs at all than having those that are unsustainable. This view has attracted attention of many researchers, development practitioners, organizations and governments of developing nations to research into how to enhance performance of the Microfinance Sector. As pointed out earlier, the core business of MFIs is to develop methods that can enable them to extend financial services to the hitherto un-bankable. However, in Ghana like most countries, the regulatory framework of MFIs does not allow all the various tiers/ categories of MFIs to accept deposit. Meanwhile, the findings of Nyamsogoro (2010); Khachatryan (2013) and Rossel-Cambier (2012) Hartarska, Parmeter and Mersland (2011) established that Product types affect the sustainability of MFIs. Also Kipesha and Zhangi, (2013), citedCGAP, 2004 which stated thatMFIs are likely to achieve sustainability and profitability, when they offer better products and services that meet clients' needs.

Though, considerable studies have been undertaken, they were mostly focused on determining either factors affecting performance of MFIs or assessing the effects of other varied variables, such as age, capital structure, corporate governance, legal status and outreach just to mention a few on the financial performance of MFIs services (Sekabira, 2013; Quayes, 2012); Kipeshaet al, 2013; Zerai and Rani, 2012; Rai, 2012; Nyamsogoro, 2010 and Kipesha, 2013). Only limited studies have been conducted on the effects of the core products of MFIs on their sustainability (Hartarskaet al, 2011; Khachatryan, 2013; Rossel-Cambier, 2012 and Kinde, 2012). Even with these studies the focus are on how micro-savings combined with micro-credit help to promote the sustainability of MFIs or reduce default rate and not on estimating the effect of each of these services. The study of Hartarska, Parmeter and Mersland (2011) concluded that financial performance of MFIs varies across the type of services and country where the MFIs operate.This studytherefore fills the gap in

knowledge by examining the effect of these core services on the financial performance of MFIs in Ghanaian context.

Addressing the gap will be useful to the industry and other stakeholder since it will bring to light which of the core services provided is more crucial to the sustainability of the MFIs.It will also bring to the attentionof MFIs' managers especially those which offer combined services toformulate policy and strategies that can help reduce the associated cost and risk relating to each service. In addition, it will also point out the stakeholders if service diversification is crucial to the sustainability of MFIs.

1.2 Purpose of the Study/ Research Question/Objective

The purpose of this study is to investigate the effect of micro-credit and micro-savings on the sustainability of MFIs.The objective of the study is to examine the effect of micro-credit and micro- savings on the financial performance of Microfinancial institutions. Relating to the objective, the research question is stated as follow: What is the effect of micro-credit and micro- savings of the financial performance of Microfinancial institutions?

1.3 Definition of Terms

Financial performance: Financial performance of MFIs is viewed from two ways. That is profitability and sustainability of the institution. The profitability measure focuses on shareholders' wealth which is mostly measured by return on asset and return on equity. It shows the ability MFIs generates excess funds for reinvestment and expansion (Kipeshaet al, 2013; Kar and Swain, 2013). The sustainability measure focuses on the survival of the MFIs to continue to render services that meet the needs of their clients. It therefore, refers to the ability of MFIs to generate revenue to cover their cost of operation without depending on external subsidies (Kipesha and Zhang, 2013). According to Khachartryan(2013)and Kinde 2012) Sustainability is measured at two levels. That is, financial sustainability and operational sustainability. The financial sustainability is a measure of the ability of MFIs to cover cost of operation from operating revenue and unsubsidized capital (Kipeshaet al, 2013).

Operational sustainability is a measure of the ability of MFIs to generate revenue through its operation to cover their cost of operation regardless of whether it is subsidized or not (Meyer, 2002 cited in Kinde, 2012). It is therefore a break-even measure where total revenue equals total operating cost. The standard measure according to Khachartryan (2013) includes operational self-sufficiency and portfolio at risk. The focus of this study is on sustainability of MFIs. For the purpose of this studyoperational sustainability, is used as a measure of the financial performance of MFIs. This is in line with the view of Kipeshaet al (2013), who stated that sustainability of MFIs is a step towards profitability and this starts with operational sustainability. Two key proxy indicators of operational sustainability are operational self-sufficiency and portfolio at risk > 30 days as indicated by Khachartryan (2013). At least one of these proxies have been used by other researchers like (Kipeshaet al, 2013; Karet al, 2013)

Micro credit

Micro credit is the various loan products offered by a lending institution to its customer (MicroBanking, 2009).The Natural logarithm of total gross loan portfolio was used as a proxy for micro credit. This is because the loan portfolio of lending institutions is a measure of the different credit products offered by them to their

customers. Also Vingo (2012) found that gross loan portfolio relates positively to sustainability of MFIs and was used by Tehuru, (2013) as a proxy for micro credits.

Micro-savings

Ledgerwood (2002 cited by Khachatryan, 2013) define saving as putting aside a certain sum of money to be accessible in the future in exchange for a series of savings made now.According to Khachatryan(2013), it could be compulsory or voluntary savings. The various savings products and the amount deposited in the accounts constitute the total deposit of any deposit taking institution. For the purposes of our study, the Natural logarithm of total deposit was used as proxy indicator for micro-savings.

2. LITERATUR REVIEW

This sub-section presents review of theories that underpin the theoretical bases of the study. It also reviews empirical literature that indicated the gaps in literature.

2.1. REVIEW OF THEORIES

The Theory of Economies of Scale

The Theory of Economies of Scale is a theory which is of interest to the study. This theory has been accredited to the renowned Economist, Alfred Marshall who devoted several pages in his Book, Principles of Economics to the discussion on the Internal Economies of Scale (Marshall, 1910). Marshall postulated that there is positive relationship between scale of production and efficiency which ultimately translates to decreasing cost of production. According to him large scale production promotes different economies of scale such as economies of skills, economies of machinery and economies of material. With the economies of machinery, Marshall was of the view that firms which engage in large scale production will keep the utilisation of their equipment steadily high. Since such machines are fixed full utilisation will result in reduction in per unit cost of production. Such large scale firms also have more resources to spend and have easy access to credit and other related benefits. The economies of skill relate to large labour force and therefore stand to benefit from specialisation and division of labour.

He was quick to add that firms also do benefit from what he referred to as external economies as well. These are positive externalities shared by all firms in the industry. It is larger external changes in government policies, infrastructure, social amenities and technological development that are shared by all firms. He however, pointed out that internal economies of scale is firm specific and therefore gives greater competitive edge to firms.

He also touched on the age of the firm. To him firms that have existed for long can have better access to resources and have greater economies of scale.

His theory has been critiqued by writers like (Witaker, 1987) who were of the view that Marshall's theory can best be practised in imperfect or monopolistic market and not in modern perfect market (Lavizzi, 2001). Notwithstanding this criticism, Khachatryan (2013) applied this theory in his study. This theory is applicable to our study because our main focus is to examine the effect of micro-savings and micro-credit on the financial performance of MFIs by controlling for size of the firm.

The Industry Life Cycle Theory (Alfred Marshall)

This theory has also been accredited to the work of Alfred Marshal. He postulated that the performance of industry should be viewed over time. The theory divide the life cycle of industries into five stages namely: the pioneering development stage; rapid accelerating stage; Mature growth stage; stabilization and market maturity and Deceleration of growth and decline stage. With this theory the first three stages (the pioneering development stage; rapid accelerating stage; Mature growth stage) of industry life experiences progressive increment in performance but decline in performance from the last two stages (stabilization and market maturity and Deceleration of growth and decline stage). This theory is applicable to the study because, the age of the firms is included in the financial model as controlled variable.

2.2.Empirical perspectives

This sub section focuses on review of work of prior researchers in order to sharpen the focus of the study as well as to establish gaps.

Kipesha(2013), studied the impact of size and age on the performance of MFIs in Tanzania. The study used panel data of five years of 30 MFIs in Tanzania. The study indicated positive impact of firm's size which was measured by total assets and number of borrowers. The study also found positive impact between the age of the MFIs and efficiency, sustainability and revenue level but negative impact on profitability. He concluded that both size and age impact on the performance of MFIs. His study however found negative relationship between size, measured by staff size and efficiency, sustainability and profitability.

Although his study examined the impact of a number of factors indicated above and established their relationship and impact, it did not consider the effect of the main products offered by the MFIs on their performance. This study therefore fills these gaps by establishing the effect of services offered by Microfinancing being measured by micro-credit and micro-savings on their financial performance.

Vingo (2012), Studied the effect of capital structure on performance of Microfinancial Institutions. He carried out a cross- country analysis and a case of Vietnam. The ordinary Least Squared Method was used to link capital structure to performance of MFIs. The study established that leverage in case of profit- making MFIs has significant effect on their sustainability. This confirmed the findings of Kar (2011) that increasing leverage increases the profitability of MFIs. The study concluded that debt including savings mobilization is increasingly becoming preferred source of funding for profit- making MFIs. He also established that Regulated MFIs which are profit oriented and used more commercial funds are more sustainable. The findings again revealed that Gross loan portfolio is positively related to Sustainability as well as profitability. The study concluded that increased in outstanding loan is likely to promote internal economies of scale which will enable MFIs to achieve higher self-sufficiency.

Although Vingo(2012) discussed wide range of issues relating to Microfinancing, the study did not discuss any theory in the literature review to provide theoretical base for the study. Beside the methodology indicates panel dataset was used, but it failed to mention the number of MFIs sampled as well as the year range. In relating the scope of operation of MFIs (services offered) the study used only gross loan portfolio though Micro-savings (deposit) has equally become an important product offered by MFIs. This study fills these gaps by including micro-credit (deposit) in the scope of operation as well as the credit implementation processes. It

also discusses the theory of economies of scale, the stakeholder theory and Industry Life Cycle theory to form the theoretical base of our study.

Sabhatu (2011) studied Management of Savings and Credit Cooperatives in Ethiopia by identifying factors which affect the performance of Savings and Credit Cooperatives. The study used qualitative methods and identified the following as factors that affect the outreach and sustainability of savings and credit Cooperatives in Ethiopia: lack of awareness and poor savings culture, weak organizational arrangement and governances, policy and regulatory environment, lack of differential products, weak institutional capacity and low capital baseamong others.

Furthermore, although the study identified lack of differential products as one of the factors that affect outreach and sustainability of savings and credit Cooperatives; like Kinde (2012),it only identified factors butfailed to carry out scientific analysis to establish the effect of these products on the performance of the institutions.

Magali(2013) sought to investigate whether the rural Savings and Credit Cooperatives Societies (SACCOS) in Eastern, Central and Northern zones of Tanzania were still sustainable after the phasing out of capacity building projects in 2013. The study applied qualitative and multivariate regression analysis and revealed that the SACCOS were not sustainable because of high NPL and failure to issue new loans from 2006-2013. However, deposit and age influenced sustainability positively which confirms the findings of Kipesha (2013). In addition loan size has significant effect on sustainability of MFIs such the larger the loan size the more sustainable the institutions. This because larger loan size reduces cost associated with loan screening and monitoring.

The study also revealed that savings and deposit to total assets influence outreach negatively. This is in line with the findings of Kar (2011) which shows negative impact of leverage on outreach but contrary to the findings of Khachatryan (2013) who found that institutions which offer deposit have wider coverage of outreach.

His study did not focus on the effect of the service offered by the institutions and therefore was not geared towards improving the performance of the MFIs but just to establish the state of affair of the institutions after the state's support was withdrawn.

Kar (2011) used panel dataset of 782 MFIs across 92 countries, and found decreasing leverage with the sustainability of the MFIs. Also, leverage had negative impacts on outreach. The study confirmed the agency theory by stating that increasing leverage raise the profitability of MFIs. This study like Kipesha (2013) considered the effects of debt and other variables on the performance of MFIs but not the core products.

Khachatryan (2013) linkedservices (micro credit and micro savings) and capital structureto the social performance and financial of Microfinance Institutions of Central and Eastern Europe and the New Independent state. He used Propensity Matching Score (PMS) to analyze the effects of how micro- saving combined with lending can help reduce default, hence promoting the sustainability of MFIs. The study found that Microfinance Institutions which accept deposits are more sustainable and cover wider outreach and this confirms the findings of Rossel-Cambier, 2012 but contrary to that of Hartarska, et al (2011). He

recommended that deposits should be encouraged since it is a better way to tailor better Microfinance services to the needs of the Microfinance service users. He also found that portfolio quality is on the average less risky for institutions that do not accept deposits compared to those which accept deposits. The focus of Khachatryan (2013) was on how savings when combined with lending can help reduce loan loss. Besides, the study used experimental model which is best used when the researcher has total control over the observed variables. But in social science one cannot have absolute control over the observed. More so the fact that researcher used secondary data means he had no control over the observed variables. This means the analytical model may affect the validity of the findings.

Hartarska, et al (2011), studied joint production of microloans and micro deposits on economies of scale of MFIs from over 50 countries. Their study adopted quantitative approach. They made use of semi-parametric smooth coefficient model to estimate a generalized cost function for a dataset from rated MFIs with over 777 annual observations on MFIs from over 50 countries. Their findings indicate that economies of scale are significant across both models since in both models, over 70 percent of the MFIs in the dataset experienced reductions in cost by offering both savings and loan services. They also find that not all MFIs that offer micro-savings are sustainable. They therefore argued that if delivery of savings is important from policy perspective, however, it should not be expected to promote financial sustainability of all MFIs in every environment. This finding is contrary to that of Khachatryan, 2013 and Rossel-Cambier, 2012, who established that combined service promotes sustainability of MFIs. This may be due to the differences in scope of coverage of the study area. Their result again showed that economy of scale varies across the type of services and country where the MFIs operate. This implies that the environment in which MFIs operate affects their cost economies. Another finding was that lending methodology affects the scope of economies, in such that MFIs using individual lending have higher scope of economies than those using group lending and village banks.

Though their study linked both services to performance of MFIs they found that not all MFIsfrom all countries are able to deliver micro savings in a sustainable manner, thus providing justification for such a study in Ghana.

Another study which examined the impact of combined multiples of financial products on performance of MFIs was carried out by Rossel-Cambier (2012). The study explored the impact of combined microfinance services (credit plus savings or insurance) on poverty outreach in Latin America and the Caribbean. The study adopted quantitative approach and sampled 250 MFIs covering the fiscal year of 2006. The study used OLS to estimate the impact. The findings revealed the impact of combined service on the depth of outreach is marginal though statistically significant at least one of the variables of interest (efficiency, productivity, sustainability or portfolio quality indicators). This is contrary to the findings of Khachatryan, 2013 who established that MFIs which offer microcredit combined with savings perform better in terms of outreach. However, like Khachatryan (2013) and Hartarska,et al (2011), outreach was used as a proxy for the social performance.

Kinde (2012) carried out research into factors affecting sustainability of Microfinance Institutions in Ethiopia. The study adopted quantitative approach using a balanced panel from 14 Microfinance Institutions over the period of 2002-2010.

Study revealed positive and significant effect of loan portfolio on sustainability of Microfinance Institutions. Kinde (2012) concluded that Microfinance Institutions should increase the number of borrowers so that they could increase the volume of loanable assets. Also they should increase the average loan size since that will improve financial sustainability. His study however, revealed negative relationship between number of borrowers and profitability. Kinde (2012) recommended further research into other aspects of Microfinance Institutions including Microfinance Institutions products delivery methodology. This is because more clients with larger loan enables Microfinance Institutions to enjoy economies of scale hence reduced cost which will lead to sustainability.Kinde, like Sabhatu (2011) and Tehuru only identify the factors affecting the sustainability of MFIs and not towards assessing the influence they exert on their sustainability.

Tehuru, (2013) studied in the financial determinants of sustainability of Microfinance Institutions in East Africa. He employed unbalanced Panel Data from 23 Microfinance services. Using, Binary and Ordinary Probit regression modelthe finding showed that micro-credit, measured by gross loan portfolio had positively significant effect on sustainability. The study however revealed that breadth of outreach and deposit mobilizations are not important determinants of sustainability of Microfinance Institutions. His study only considers financial performance and not social performance.

3. METHODOLOGY AND DATA

3.1 Data Description

This section describes type and source of data, population, sample size and justification.

The study examines the effect of micro-credit and micro-savings on the financial performance of MFIs in Ghana. The study adopts quantitative approach. It uses secondary data obtained from the Microfinance Information Exchange database (the MixMarket online platform 2013). The Microfinance Mix market is a platform where MFIs all over the world voluntary report their financial and operationaldata to. It is a credible source used by many microfinance researchers. The study sampled 16 of the 32 MFIs operating in Ghana which had reported to the platform. The selection of this sample size is based on the criterion that the institution should report at least three years within the years of study and must still be in operation as MFIs as at 2013 when data was obtained. Also must haveinformation on their credit products and pricing on the McrofinanceTransperency.org. The data obtained was unbalanced panel data such that some of the MFIs reported for just three years, whiles some for four years and abovefrom 2006 to 2012.

3.2 Model Specification and Estimation

The study use two indicators as proxies for services offered (natural log of gross loan portfolio as micro-credit and natural log of total deposit as micro-savings) as the independent variables. The study also uses operational self- sufficiency and Portfolio at risk greater than 30days as proxy indicators for sustainability of the MFIs (the dependent variables). The study controls for three categories of variables namely, industry benchmarking variable (diamond rating); group dummy variable (regulation) and institutional specific variables (age, size, profit status, Financial Intermediation, target market, scale and outreach). These variables are controlled based on discovery from literature and the result from the correlation matrix which shows significant relationship of these variables with the financial performance of MFIs. Detail explanation of these variables is captured under definition of variables.

We employed general panel regression analysis model which was expressed as $Y_{it} = \lambda + \beta X_{it} + e_{it}$ …… (1)and was also used by Kipesha and Zangi (2013).

Where : Y_{it} = is the dependent variable, λ is the intercept term, β is a k x 1 vector of parameters to be estimated on the explanatory variables, X_{it} is the 1 x k vector of observations on the explanatory variables, t denotes time period t=1,…., T, i denote cross section i=1,…..,N.

Extending equation1, our empirical financial performance panel regressions model is captured below as:

$$Y_{it} = \beta_0 + \beta_1 \text{MicroCredit}_{it} + \beta_2 \text{MicroSavings}_{it} + \beta_3 (\text{MicroCredit}_{it} * \text{MicroSavings}_{it}) + \alpha_i \text{CV}_{it} + \varepsilon_{it} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (2)$$

Where: $Y_{it} = \begin{bmatrix} \text{FIN\_PERF\_1} \\ \text{FIN\_PERF\_2} \end{bmatrix}$ is a 2 x1 vector of financial performance indicators where:

$$\text{FIN}_{\text{PERF}_1} = \text{operational self} - \text{sufficiency}$$

$$\text{FIN}_{\text{PERF}_2} = \text{portfolio at risk} > 30\ days$$

$$\beta_0 = \text{an autonomous term}$$

β_1,β_2, β_3 are slope coefficients measring both the individual and interactive effects of micro-credit and micro-savings on financial performance of MFIs

$\alpha_i = \alpha_1, \alpha_2, \dots \alpha_N$represent slope coefficients of N control variables as captured below:

- Age of MFI measured ; New= 1, young =2, mature =3
- Size of MFI computed as natural logarithm of total assets and
- Diamonds rating; 1 = high diamond rating and 0 = otherwise
- Regulation ; Non-Regulated =0, Regulate =1
- Financial Intermediation ; HighFin Intermediation = 1 and 0 =otherwise
- Outreach ; large =1 and 0 otherwise
- Profit Status ; Profit =1 ,0 if non-for-profit
- Scale level ; large scale =1 and 0 if otherwise
- Target market; HighTargetMarket =1, 0 if otherwise

In effect, the $\text{CV}_{it} = \begin{bmatrix} \text{Age} \\ \text{Size} \\ \text{D Rating} \\ \text{Reg Status} \\ \text{Fin Inter} \\ \text{Outreach} \\ \text{ProfitStatus} \\ \text{Scale} \\ \text{T Market} \end{bmatrix}$, representing a 9 x 1 matrix of control variables

e_{it} is defined as the error term.

Definition of variables and treatments

Micro credit: The study uses natural log of gross loan portfolio as micro-credit.The study also uses natural log of total deposit as micro-savings. These two variables have been used as proxies for services offered by MFIs because; they are the core services and are also under strict regulation and supervision by Bank of Ghana.AlsoVingo (2012) found that gross loan portfolio relates positively to sustainability of MFIs and was used by Tehuru, (2013) as a proxy for micro credits.Operational Self- sufficiency (FIN_{PERF_1}) measures the ability of the MFIs to cover its operating cost from revenue generated irrespective of the source of funds. Portfolio at risk greater than 30 days (FIN_{PERF_2}) is a standard measure of the MFIs' portfolio quality. These two variables are used as proxies for financial performance since Kharchatryan (2013) stated that they are proxyindicators for operational sustainability.Besides, Operational self-sufficiency was used by Kipeshaet al (2013) as a measure of financial performance and Portfolio at risk greater than 30days was used by Karet al (2013).Besides, the study controlled for age to allow for the possibility that age of the institutions will influence efficiency in managing cost associated with the core services offered. The age dummy grouped MFIs into three categories: New equal to one Young equal to two and Matured equal to three.The study expects age to be positively linked to sustainability of the MFIs.The binary variables Regulation and Profit motive are categorised into two. In the model one is equal toinstitutions that are regulated; for profit and zero is equal to Non-regulate and not –for- profit.The study also controlled for size measured by the natural log of total assets. These variables were also controlled by Karet al (2013) and Kharchatryan (2013).The study also controlled for financial intermediation as dummy variable. This is because MFIs which receive financial support in the form of subsidies, donation or grants will have access to cheaper source of funding. It was grouped into none, low and high. In the model one is equal to institutionsfinancial high intermediation and zero for otherwise. Target marketdummy is based on average balance of loan.It was grouped into four categories: Small business, Low-end, Broad- end and high-end.In the model high targetmarket (T market) is equal to one and zero otherwise. This variable was also controlled by Kharchatryan (2013). Diamond ratingdummy variableis how the various MFIs are rated in terms pricing transparency and following standard accounting reporting. It indicates proper internal control and efficiency which is likely to reduce possible operational risk therefore the study expects it to have positive effect on performance (MicroBanking, 2009). In our model one is equal to high rating (Drating). The next variables are outreach and level of scale. The outreach dummy variable indicates the poverty level of the different categories of client reached.Whiles level of scale measure indicates the number of poor the MFIs serve. It is measured by borrower per staff (MicroBanking, 2009) as large, medium and small.In the model one is equal to large (scale and Outreach) and zero if otherwise.

Diagnostic tests: To decide on which panel data parameter estimation will best suit our data, we performed series of diagnostic test related to panel data analysis. The study performed Hausman test in order to know whether the fixed effects model provided a better model fit over the random effects model or vice-versa. The p-value (≥chi square) of the Hausman test is p= 0.0065 ≤0.05. This implies that the fixed effects model provides a better fit for the models than the random effects model. We however, test for panel effects using Breusch-Pagan Lagrange multiplier (LM) to decide between random effects regression and a simple OLS regression. The results of the Breusch-Pagan Lagrange multiplier (LM) indicates that there is no evidence of significant differences across MFIs (no panel effect) (Prob, 0.1970>; chi-square1. 66 ≥0.05); meaning that the random effects model is not appropriate when compared with the pooled OLS model. We further tested for

the following: cross-sectional dependence/contemporaneous correlation using Breusch-Pagan LM test of independence, heteroskedasticity using modified Wald test for GroupWise heteroskedasticity, autocorrelation using the p-value of F statistics based on the Wooldridge test for autocorrelation for panel data is lesser than 0.05. The p-value of the test were less than 0.05 which shows the presence of cross-sectional dependence/contemporaneous correlation, heteroskedasticity and autocorrelation are all present in our data set. Such conditions could best be dealt with using the Generalized Least Squares estimator if the data is highly balanced (Greene, 2012; Maddala andLahiri, 2006. The unbalanced nature of our panel data therefore could not allow ours to use the generalized least squares estimator. We therefore employed Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) recommended by Beck and Katz (1995) in dealing with the problems of Serial Correlation cross-sectional dependence and heteroskedasticity since the estimates are BLUE for the estimation of model 1.

4. DATA ANALYSIS AND RESULTS

This section first examines the effect of micro-credit and micro-savings on the operational self-sufficiency of MFIs. The (PCSEs) results show an R-squared of 0.6396 and p-value of chi –square statistic =0.0000). These indicate that the independent and the control variables (age, size, credit rating, regulation status, financial intermediation, outreach, and profit status, microcredit and micro-savings services offered) could significantly accounted for 63.96% of variations in operational self-sufficiency of MFIs.

The results indicate that age of MFI has positive statistically significant [B= 0.1084316, p= 0.015 ≤0.05] effect on financial performance 1 (operational self-sufficiency). This means that as MFI's age status changes from new, to young, to mature, their operational self-sufficiency is likely to increase which may be due to improved efficiency in operations and management. Regulation status has positive and statistically significant (B=0.2557155; p=0.000 ≤0.05) effect on OSS. This means that though regulation goes with cost to the MFIs, the benefits gained from reduction in risk exposure far off-set the cost and is thereby likely to makeregulated MFIs more sustainable. Besides, financial intermediation and outreach were also control variables that had significant positive effects on operational self-sufficiency of MFI's (p≤0.05, 0.10). However, Size (B=-0.2830912; p= 0.009 ≤ 0.10) and profit status (B=-0.3485346; p= 0.024 ≤ 0.05) have negative but significant effects on operational self-sufficiency. This means that MFIs which increase total asset by aggressive branch expansion and increased credit portfolio but of poor quality and aggressive profiteering are likely to expose themselves to extra operating cost and risk. Diamonds rating had negative but significant effects (B=-0.1856376; p= 0.026*≤ 0.05) on operational self-sufficiency. Of all the control variables, only scale and target market had insignificant effects on OSS on MFI's (p≥0.05, 0.10).

Natural logarithm of micro-credit exerted a significant positive effect on operational self-sufficiency (B=0.1402319; p ≤0.05). In other words, if microcredit increases by 1 unit operational self-sufficiency of MFIs is expected to increase by 0.1402319 units. This literally implies that as MFIs increase their gross loan portfolios, their expected financial performance in terms of operational self-sufficiency increases significantly. This because, although lending goes with cost and associated default risk, if effective credit management practices are put in place the revenue generated in the form of interest income and fees and other charges will outweigh the cost. Natural logarithm of micro-savings, on the other hand, has a negative effect on operational self-sufficiency though statistically insignificant (B=-0.1296475; p= 0.173≤0.05), meaning that a 1 unit increase in micro-savings (deposits) could lead to a 0.1296475 decrease in operational self-sufficiency of

MFI's. This is because mobilizing micro- savings is labour intensive and costlysince officers have to engage in door to door services. Also there are instances where some officers either run away with the amount collected or understate the amount collected from customers. Besides, eventhough it has been argued that deposits offer cheaper funds for operation, the increasing competition for customers' deposit is forcing MFIs to offer higher interest rate on customers' deposit so as to attract such funds. These might have partially accounted for the negative effect. The interaction between credit and savings has very weak and statistically insignificant effects on OSS of MFIs (0.0076086; p 0.278≥0.05). Refer to table 4.1 below.

Table 4.1 Effects of Micro-Credit and Micro-Savings on Financial Performance Indicator 1(operational Sustainability)

Number of gaps in sample: 1
(note: computations for rho restarted at each gap)

Prais-Winsten regression, correlated panels corrected standard errors (PCSEs)

Group variable: CROSSID		**Number of obs**	**= 77**
Time variable: YEAR		**Number of groups**	**= 16**
Panels: correlated (unbalanced)		**Obs per group: min**	**= 3**
Autocorrelation: panel-specific AR(1)		**avg**	**= 5.133333**
Sigma computed by pairwise selection		**max**	**= 7**
Estimated covariances = 120		**R-squared**	**= 0.6396**
Estimated autocorrelations = 16		**Wald chi2(9)**	**= 362.31**
Estimated coefficients = 13		**Prob> chi2**	**= 0.0000**

Fin_Perf_1	**Panel-corrected Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**	**Interval]**
Age	**.1084316**	**.0446391**	**2.43**	**0.015***	**.0209405**	**.1959226**
Size	**-.2830912**	**.10906**	**-2.60**	**0.009****	**-.4968447**	**-.0693376**
D_Rating	**-.1856376**	**.083631**	**-2.22**	**0.026***	**-.3495514**	**-.0217239**
Reg_Status	**.2557155**	**.05749**	**4.45**	**0.000***	**.1430371**	**.3683939**
Fin_Inter	**.0651591**	**.036412**	**1.79**	**0.074****	**-.0062071**	**.1365252**
Outreach	**.1818242**	**.0500416**	**3.63**	**0.000***	**.0837444**	**.2799039**
Profit_Status	**-.3485346**	**.1542212**	**-2.26**	**0.024***	**-.6508026**	**-.0462665**
Scale	**.0580401**	**.0872337**	**0.67**	**0.506**	**-.1129348**	**.229015**
T_Market	**-.0707744**	**.0579581**	**-1.22**	**0.222**	**-.1843703**	**.0428215**
Ln_Credit	**.1402319**	**.0707752**	**1.98**	**0.048***	**.0015149**	**.2789488**
Ln_Savings	**-.1296475**	**.0951696**	**-1.36**	**0.173**	**-.3161766**	**.0568815**
Ln_CrexLn_Sav	**.0076086**	**.0070121**	**1.09**	**0.278**	**-.0061348**	**.021352**
_cons	**3.518392**	**.7447757**	**4.72**	**0.000**	**2.058658**	**4.978125**

rhos = .4316751 -.0782639 .0824643 .2719338 .1611257 ... .4838116

**Significant at 0.05 level*
***Significant at 0.10 level* **Source: Author's Analysis (2016).**

We again examine the effect of micro-credit and micro-savings on portfolio at risk less than 30 days (PAR30). Again, the series of diagnostic test favour the Pooled Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) .The (PCSEs) results show an R-squared of 0.3308 and p-value of chi – square statistic =0.0000). These indicate that the independents and the control variables (age, size, credit rating, regulation status, financial intermediation, outreach, and profit status, microcredit and micro-savings services) could significantly accounted for 33.08% of variations in Financial Performance Indicator 2(Portfolio at Risk > 30 days) of MFIs. Though, the R-squared is only 0.3308, Correron (2009) and Ganta (2010) Cited in Kinde (2012), stated that for panel data, R^2 above 0.2 is still large enough for reliable conclusions.

From the results, age again exerts significant positive effect on portfolio at risk (>30 days) of MFIs (B=0.0287534; p=0.004≤0.05). Target market also exerts significant positive effects on portfolio at risk (>30 days) of MFIs (.0129548; p=0.093≤ 0.10) whiles outreach exerts a significant but negative effect on portfolio at risk (>30 days). This means outreach which measures depth of outreach rather helps to reduce credit going bad.

The result also shows that both Micro-credit and micro-savings have positive but insignificant effects on portfolio at risk (0.0149595; p= 0.134≤ 0.10) and (0.016483; p=0.235≤ 0.10) respectively. The interactive effect (micro-credit x micro-savings) rather exerted a negative, though very small and insignificant effect on portfolio at risk (-0.0009444; p=0.379 ≥0.10).**Refer to table 4.2 below.**

Table 4.2Effects of Micro-Credit and Micro-Savings on Financial Performance Indicator 2(Portfolio at Risk > 30 days)

Number of gaps in sample: 1						
(note: computations for rho restarted at each gap)						
Prais-Winsten regression, correlated panels corrected standard errors (PCSEs)						
Group variable: CROSSID				Number of obs =	77	
Time variable: YEAR				Number of groups =	16	
Panels: correlated (unbalanced)				Obs per group: min =	3	
Autocorrelation: panel-specific AR(1)				avg =	5.133333	
Sigma computed by pairwise selection				max =	7	
Estimated covariances = 120				R-squared =	0.3308	
Estimated autocorrelations = 16				Wald chi2(12) =	64.56	
Estimated coefficients = 13				Prob> chi2 =	0.0000	
			Panel-corrected			
Fin_Perf_2	Coef.	Std. Err.	z	P>z	[95%	Conf. Interval]
Age	.0287534	.0099233	2.90	0.004*	.0093042	.0482027
Size	-.0140085	.0167138	-0.84	0.402	-.046767	.0187499
D_Rating	-.0015778	.0128614	-0.12	0.902	-.0267856	.02363
Reg_Status	.0198651	.0451838	0.44	0.660	-.0686934	.1084237
Fin_Inter	-.0037748	.0115588	-0.33	0.744	-.0264297	.01888
Outreach	-.039296	.0147813	-2.66	0.008**	-.0682669	-.0103252
Profit_Status	.0576228	.0384043	1.50	0.134	-.0176484	.1328939
Scale	.0160349	.0196636	0.82	0.415	-.0225051	.0545749
T_Market	.0129548	.0077091	1.68	0.093**	-.0021547	.0280644
Ln_Credit	.0149595	.0099911	1.50	0.134	-.0046226	.0345416
Ln_Savings	.016483	.0138742	1.19	0.235	-.01071	.0436759
Ln_CrexLn_Sav	-.0009444	.0010739	-0.88	0.379	-.0030491	.0011603
_cons	-.1335812	.1719166	-0.78	0.437	-.4705315	.2033691
rhos = -.2805852 .1583731 .2017537 .1493062 -.0922131 ... .2100357						

**Significant at 0.05 level*

***Significant at 0.10 level*

Source: Author's Analysis (2016).

5. DISCUSSION OF RESULTS AND CONCLUSIONS

5.1DISCUSSION OF RESULTS

The resultsshow that micro-credit has positive and significant effect on OSS whichconfirms the findings of Tehuru (2013) and Kinde (2012) who also found positive effect of gross loan portfolio on sustainability of MFIs. This therefore confirmsEconomies of Scale theory, since increase in loan portfolio will promote the sustainability of the MFIs.

The results again indicate that age of MFI has a positive and statistically significant effect on operational self-sufficiency and Portfolio at Risk > 30 days.This means that as MFI's age status changes from new, to young, to mature, their operational self-sufficiency is likely to increase. This confirms the findings ofKipesha (2013) and Magali(2013) who found positive effect of age on the operational self- sufficiency of MFIs.It as such confirmed the theory of Industry Life Cycle. The positive co efficient of age on Portfolio at par greater than 30 days has to be interpreted with care. The positive effect rather indicates that age rather increases portfolio at risk. That is increase credit portfolios that will go bad. This result is quiet interesting since one will assume that the more MFIs stay in business the more experience they will get in credit management and will expert age to contribute to reduction in portfolio at risk. This may be due to the progressive lending methodology applied by MFIs. This means as the MFIs increase in age, customers who equally have long association with them are likely to benefit from larger amount of credit facilities. This may expose them to default risk if the funds are not properly utilized. This is in line with Hermes (2011 cited in Magali, 2013), who found that older firms are less sustainable.

Size of MFIs have a negative significant effects on operational self-sufficiency and this is line with Kar and Swain (2013) but contrary to the findings of Nyamsogoro (2010) and Kipesha(2013) who found size positively affecting sustainability of MFIs. This may be due to aggressive branch expansion and increased credit portfolio but of poor quality.

Outreach has positive significant effects on operational self-sufficiency but negative on Portfolio at risk this confirms the findings of Quayes (2012); Kipesha and Zhangi (2013) but contrary to the findings of Tehuru,T.A (2013).This may be due to the recognition by the very poor that, they need to honour their repayment obligation to the only category of institutions which are ready to attend to their financial needs.

5.2.Conclusions and Recommendation

The aim of the study is to examine the effect of the two core financial services on the sustainability of MFIs. The study was conducted using a sample of 16 MFIs from Ghana. The Pooled Prais-Winsten regression with correlated panels corrected standard errors (PCSEs) results show that Micro-credit contributes to operational sustainability of MFIs. Micro-savings rather had negative influence on the operational sustainability of MFIs. Also,control variables such as age, regulation, and outreach have exerted positive influence on the effect of the core services. Whiles other control variables such as size and profit status retard the contribution of the two core financial services to sustainability of MFIsThe study fills the knowledge gap by establishing the effect of each of the core financial services on the sustainability of Microfinancial institutions in Ghana.

The study recommended that MFIs should adopt proper credit management practices to reduce the risk associated with credit sincelending has positive impact on their sustainability. Also, MFIs should use

technological devices like mobile phones and lockboxes to reduce the cost associated with regular visit by the field officers and the risk of field officers running away or understating clients' deposits.

Regulation contributes to sustainability of MFIs; Managements of MFIsshould be given adequate education on the relevance of complying with regulation. Also Bank of Ghana should decentralize its supervision duty. They must promote grassrootssupervision from the district assembly level. This will promote closer linkage between the regulator and the MFIs.

Aggressive profiteering can render MFIs unsustainable. MFIs therefore should not focus only profit but should be concern with their continuous existence. This will guide them to avoid engaging in activities and practices that are likely to result in their collapse.

The study calls for further study into difference in the performance of MFIs that offer combined service and those that offer only micro-credit.It also calls for examination of the effect of pricing of products of Microfinancial Institutions on their financial performance.

REFERENCE

Augsburg, B. (2009). Microfinance- Greater Good or Lesser Evil? Thesis submitted in partial fulfillment of the requirement of Maastricht University for the Doctor of Philosophy

Ashraf, M. A. & Ibrahim, Y.Bt. (2013). An Investigation Into The Barrier To The Rural Poor Participation In Mfis: The Case Of Bangladesh. International Journal of Research In Social Sciences. 1 (2)

Bank of Ghana (2007).A note on Micro- financing in Ghana, Bank of Ghana working paper series. Bank of Ghana. Available http://www.adb.org/Documents/Policies/Microfinance/financepolicy.pdf (retrived on 18 April 2012)

Baum, C. F. 2001. Residual diagnostics for cross-section time series regression models. Stata Journal 1: 101–104.

Beck, N. L., and J. N. Katz. 1995. What to do (and not to do) with time-series cross-section data. American Political Science Review 89: 634–647.

Boateng, I. A. &Agyei, A. (2013). Microfinance in Ghana: Development, Success Factors and Challenges. International Journal of Academic Research in Accounting, Finance and Management Sciences, 3 (4), pp. 153–160

Breusch, Pagan &Goffrey. Cited in : Wooldridge, J. M. 2002. Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: The MIT Press.

Greene, W. H. 2012. Econometric Analysis. 7th ed. Upper Saddle River, NJ: Prentice Hall.

Hausman, J. 1978. Specification tests in econometrics. Econometrica 46: 1251–1271.

Hartarska V., Parmeter, C. and Mersland, R. (2011), Should All Mircofinance Institutions Mobilize Micro-savings? Evidence from Economies of Scope, Oxford Bulletin of Economics and Statistics

Hoechle, D. 2007. Robust standard errors for panel regressions with cross-sectional dependence. Stata Journal 7:281–312.

Ibtissem, B. &Bouri, A. (2013). Credit risk Management in Microfinancing: The conceptual Framework.ACRA Journal of Finance and Risk Perspectives, 2 (1) p. 9-24

Kar, A. K. (2012). Does capital and financing structure have any relevance to the performance of microfinance institutions? *International Review of Applied Economics*, *26*(3), 329-348. doi:10.1080/02692171.2011.580267

Kar, A.K & Swain, R.b(2013). Interest rate and financial performance of Microfinancial institutions: Recent Global Evidence. European Journal of Development Research 33: p. 1-20. doi: 101057/erjdr

Khachatryan, K. (2013). Managing microfinance institutions: linking performance with services and capital portfolio. Thesis Submitted in fulfillment of the requirements of the Degree of Doctor of Philosophy to the Department of Economics and Finance. University of Nice SophinAntipolis.

Kipesha E.P & Zhang, X. (2013) Sustainability, profitability and outreach Tradeoffs: Evidences from Microfinance Institutions in East Africa. European Journal of Business and Management, ISSN 22221905 (Paper) ISSN 2222-2839 (Online),5(8)

Kipesha E.F. (2013). Impact of size and size and age of firm‘s performance: Evidence from Microfinance Institutions in Tanzania, Research Journal of Finance and Accounting.ISSN. 2222-1697 (Paper) ISSN 2222-2847 (Online), 4 (5)

Magali, J.J (2013). Are Rural SACCOS in Tanzania Sustainable? International Journal of management Science and Business Research ISSN (2226-8235) vol.3. Issue1

Marshall, A. (1910) Principles of Economics, Sixth Edition, London, MacMillan and Co

Michael A., R. Duane Ireland, and Robert E. Hoskisson(2001).Strategic Management: Competitiveness and Globalization Fourth Edition. South-Western College Publishing,

Olayombo, O.O. (2012). The roles of cooperative societies in Rural Finance: Evidence from the Oguan State, Nigeria. Thesis submitted in partial fulfilment of the requirement of Doctor of Philosophy. De Montfort University, Lekoster, United Kingdom

Rossel-Cambier, K. (2010). Do Multiple Financial Services Enhance the Poverty Outreach of Microfinance Institutions? CEB Working Paper N°10/058 2010

Sabhatu, K.T. (2011). Management of Savings and Credit Co-operatives from the Perspective of Outreach and Sustainability: Evidence from Southern Tigrai of Ethiopia.‖ Research Journal of Finance and Accounting ISSN 222. 1697(Paper), 2(2/8)

The Microbanking bulletin (2009) issue No. 9. Microfinance Information Exchange, Inc.

SNAKE BITES; A FORGOTTEN MENACE IN KENYA

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ABSTRACT.

Snake bite injury is a common problem for residents of the larger Mwingi District of Kitui County in Kenya. The resultant morbidity, mortality and economic losses are enormous. This prospective cross sectional descriptive study in a single district hospital in Kenya aims to present the patient characteristics, treatments offered and to document the outcomes of snake bites, in a rural setting, of this largely forgotten menace. The study aims to rekindle the awareness to this age old problem and notes that the lower limb was the most affected, most of the snake bites occur at night and inside the houses of the victims, there's an attendant prolonged period of hospitalization from 0 to 88 days. Several patients got alternative medical treatment including; tourniquet application in 2 patients, snake stone application for 5 patients and two patients had a non specified herbal form of treatment before arrival to the hospital. That two patients had amputations, three patients required a skin graft, three patients died and the rest of the patients recovered well in the hospital. This paper concludes that most patients who receive supportive treatment with multivalent antivenin get good results however, the mortality rate and morbidity are unacceptably high in this population in comparison to other jurisdictions. The general population in Mwingi district requires public health information on measures to snake proof their houses to help reduce the menace and to avoid harmful pre hospital practices.

KEY WORDS

Snake bite, envenomation, antivenom, antivenin.

1.0 Introduction.

Africa is home to more than 400 snake species, of which about 30 are venomous species (Bernard A, (2012)). Because medical recordkeeping is so fragmented and incomplete in Africa, the exact incidence of snakebite on the continent is unknown (Bernard A, (2012), Chippaux JP, (2011), and Russell FE, (1990)). Worldwide, at least 421,000 to 1.8 million envenomings and 20,000 to 94000 deaths occur every year from snakebite; the actual numbers, could be higher (Anuradhani K, et al (2008) and Kadir, M.F et al (2015)) consequently the WHO in 2009 declared snakebite a neglected tropical disease (Bernard A, 2012) as other publishers have reported snake bites as a misunderstood problem (Ian DS et al (2009). Health authorities, meanwhile, have largely ignored the problem, both because they do not have accurate data, and thus are unaware of the incidence rates (Bernard A, 2012), Chippaux JP, (2011), and Anuradhani K, et al (2008)). The lower estimates of snakebite incidence in sub-Saharan Africa are probably a reflection of under-reporting from many parts of this region; it has been particularly difficult to find reliable data for this region, especially for East Africa (Anuradhani K, et al (2008)). The overall average frequency of snake bite in Kenya was estimated at 13.8 per 100,000 population per year (range 1.9-67.9). The minimum rate of snake bite mortality was 0.45/100,000/year (Coombs MD, et al (1997) In sub-Saharan Africa annual mortality was estimated at 7,331 (5,148-9,568), of which 97% occurred in a rural environment (Chippaux JP, (2011) More than 95% of the snakebites occur in rural Africa where antivenin therapy is not always available within 24 hours, as recommended.. In Kenya it is reported that only 27% of snake envenomation victims sought hospital treatment (Snow RW, et al (1994)). In 1971, 1972 and 1973 there were 89, 67 and 22 deaths recorded in Kenya among 47325, 46884 and 46992 deaths, respectively, from all causes (Mbindyo BS, et al (1979). Majority of the (68%) bite cases seek treatment from a traditional healer who invariably uses local herbal preparations applied to the bite site and/or in a ring around the bitten limb. Local skin incisions are also commonly practised. (Snow RW, et al (1994)). The

traditional healers have a reputation for treating difficult snake bite cases and are trusted by their patients (Bethwell OO, et al (2006)) biomedicine ignores their practice but they serve more snake bite accident victims than modern medical practitioners (Bethwell OO, et al (2006, Kihiko DK, (2013)). It is noted that the Kamba community, where this study was done, use herbal medicines influenced by the existence of an inadequate biomedical health system and cost-effectiveness (Bethwell OO, et al (2006, Kihiko DK, (2013)). The larger Mwingi District of Kitui County has some of the most venomous serpents including black mamba, green mamba, black necked cobra, and puff adders (Kihiko DK, (2013)).

2.0 Methods

A prospective cross sectional descriptive study was conducted for all patients who were bitten (as evidenced by history and a physical examination finding of fang marks) and received treatment for snake bite at Mwingi District Hospital, of Kitui county in Kenya, from August 2010 to July 2011. Mwingi district hospital serves a population of 303,828 residents of Mwingi district. Patient's demographic information, clinical presentation data, investigations, the surgical treatments offered and outcomes were the variables documented using a questionnaire. Data was coded and entered into a statistical package for social sciences version 21.0. Descriptive statistics and frequencies were employed in analysis. Categorical data was analyzed by the Chi square test and the Fischer's exact tests as appropriate and a p value of ≤ 0.05 was considered significant. Permission to carry out the study was given by the hospital's ethics and review board.

3.0 Results

Sixty five (65) patients were admitted and treated at Mwingi district hospital for snake bite injury during the study period. This gives an average hospital incidence of five patients per month (see figure one below). There was a slight male preponderance of thirty four (34) males against thirty one (31) females. The age of patients ranged from two years to sixty five with a mean of 18.1 years (std 14.48) a more youthful population was affected more as more than seventy percent of the victims are aged twenty years and below compared to the elderly population.

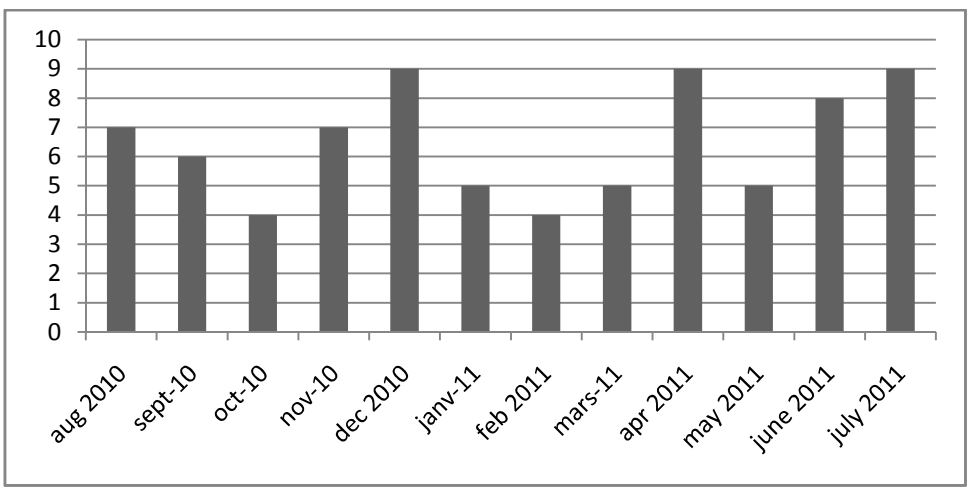

Figure one showing frequency of snake bite by month of year during the study period.

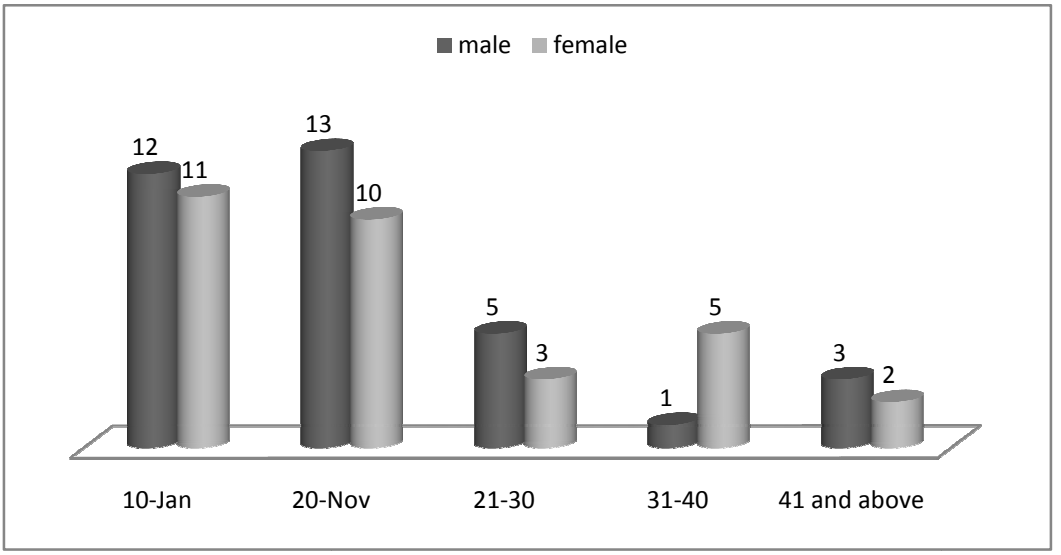

Figure two showing the distribution of bite victims by age group and gender.

There was no statistically significant difference between the sexes bitten by the snakes (p=0.452). The Most common site of bite was on the lower limbs (53.8%) followed by the upper limbs (41.5%), the head was bitten in 3.1% of cases and one patient was spit in the eyes by a spitting cobra which had invaded her chicken house as she went to check the source of commotion. Ninety four percent (n=61) of the patients had a single bite and four patients who were children of age ranging from 2-12 years had multiple bites. For an unfortunate fourteen year old boy, it was the second time he was being bitten by a snake.

Most of the patients were bitten at night (44.6%) while a sleep in their houses, other victims were bitten in the morning (10.8%), around midday (35.4%) and in the evening (9.2 %).

The commonest physical examination finding at presentation to the emergency department was a soft pitting oedema of the affected limb, followed by tissue necrosis around the site of bite. Features of systemic toxicity were present in ten patients (representing 15.4%) and they included hypotension (n=4), paraesthesias and dysaesthesia (n=5), blood oozing from site of bite (n=1). None of the patients presented with haemoptysis, haemolysis, petechiae or epistaxis as a systemic feature of anti coagulation causing venom.

	yes	no
Soft pitting oedema	50	15
bullae	2	63
Erythema/discolouration	1	64
Local tissue necrosis	32	33
Continuous blood oozing from site of bite	1	64
Systemic toxicity	10	55

Table one showing the presentation after the bite on physical exam.

The patients were hospitalized for a period ranging from 0 to 88 days with a mean of 11.72 days (std 16.2).After the bite most of the victims (n=50, 76.9%) did not receive any form of traditional treatment before they arrived in hospital .The remainder had some form of "first aid" given by their relatives before they came to hospital. These treatments included tourniquet application for seven patients (10.8%), snake stone application n=6 (9.2%), potassium permanganate application (n=1) and one other patient applied some un recognised herbal remedy. No bloodletting or mouth suctioning was reported in any of our patients.

	Yes (%)	No (%)
Antibiotics and tetanus toxoid	63 (96.9%)	2 (3.1%)
amputation	2 (3.1%)	63 (96.9%)
fasciotomy	2 (3.1%)	63 (96.9%)
Skin grafting	3 (4.6%)	62 (95.4%)
Anti snake venom	12 (18.5%)	53 (81.5%)
steroids	59 (90.8%)	6 (9.2%)

Table two showing the various treatments offered to patients bitten by snakes

Three patients died despite the medical treatment. The first a 19 year old male who was bitten once on the lower limb developed bullae and hypotension at presentation to hospital was given anti snake venom, steroids, antibiotics and tetanus toxoid he succumbed shortly after admission. The second and third were four year old males who died on the first and second days of hospitalisation respectively, one developed difficulty in breathing and another may have died from a coagulopathy, both had received anti snake venom, steroids, antibiotics and tetanus toxoid in the course of treatment.

4.0 Discussion.

This study has established that snake bites are common in Mwingi district of kitui county-Kenya. The snake bite incidence averages from four to nine patients monthly. Considering that only 27% of patients bitten by snakes in Kenya visit the hospitals for medical care the problem could be enormous (Snow RW, et al (1994)).The prevalence of snake bites could be due to the climatic conditions where the area is mostly hot and dry and a lot of farming activities take place. Secondly the kind of housing that the residents of this district have are thatch and brick walled which seems to encourage the snakes to hide in the thatch and crevices in the walls as they seek rodents and stored water in the same dwellings bringing them in direct conflict with humans (Kihiko DK, (2013)). The slight preponderance of males could be due to the activity of herding livestock in the shrubbery found in the area. The victims have been noted to be mainly youthful with age below twenty years accounting for more than 70% of the patients in this study. This compares with what was noted by Kihiko DK that 60% of his patients were children and students and that this could be due to poor judgement on the part of children as to the danger these snakes pose and the fact that most of the young are actively involved in tending for the livestock as compared to the elderly (Kihiko DK, (2013)).

The lower limbs are the most bitten site when the victims step on these snakes as they go about their activities. The Public should be educated to increase use of protective wear such as use of boots while herding livestock or walking at night to reduce the incidence of snake bite.

Children had multiple bites either a manifestation of ignorance on their part or because the snakes could outrun them as we know the black mamba which is found in this region (Kihiko DK, (2013)) can run very fast and can bite repeatedly in quick succession.

Most of the patients were bitten at night (44.6%) while a sleep in their houses this is twice the findings by Kihiko where twenty percent of the bites were at night. In Mwingi this occurred either when the victim stepped on the snake accidentally or when the snakes visited the victims' households in search of rodents, to seek warmth and stored water. Measures to snake proof homesteads such as sealing all holes and crevices, keeping lawn short, flower beds to be far from houses and traps to eliminate rodents and mice and provision of water outside the house could go a long way in dissuading invasion of snakes into human dwellings.

Most patients presented with features of local toxicity such as swelling/oedema, local tissue necrosis, bullae and erythema. Only ten of the patients had systemic features of toxicity and they were adequately treated with polyvalent antivenin though sadly three of them died.

Traditional treatments for snake bites were encountered where use of tourniquets, snake stone application, potassium permanganate and herbs were encountered. It has been demonstrated that some of these therapies can be more harmful than the bite eg application of tourniquets and therefore there is need to educate the residents of this region to abandon this harmful practices (Snow RW, et al (1994), Bethwell OO, et al (2006, Kihiko DK, (2013)).

5.0 Conclusions

This study concludes that snake bites are rampant in Mwingi district. The morbidity and mortality from snake bites is still unacceptably high in this region. Most patients who receive supportive treatment with multivalent antivenin in the hospital get good results. The general population in Mwingi district requires public health information concerning snake bites to avoid harmful pre hospital practices such as application of tourniquets. Most of the snake bites occur at night and inside the houses of the victims. Measures to snake proof the houses can help to reduce the menace.

6.0 Recommendations

The general population in Mwingi district requires public health information concerning snake bites to avoid both the snake bites and harmful pre hospital practices and that when bitten by a snake they should seek medical attention in hospitals as quickly as possible. Further, the residents should cover all holes that may lead to their houses and maintain neat well manicured lawns, and, flower beds should be away from houses. They should also seal cavities and keep rodents away from their houses and provide water outside the houses. Medical personnel should be dissuaded from unhelpful practices such as routine parenteral steroids for all snake bite victims. The state agencies must ensure availability- in adequate quantity- of multivalent antisnake venin for treatment of patients to avoid unnecessary mortality.

7.0 References

Anuradhani Kasturiratne, A. Rajitha Wickremasinghe et al. (2008). The Global Burden of Snakebite: A Literature Analysis and Modelling Based on Regional Estimates of Envenoming and Deaths. PLoS Med 5(11): e218. doi:10.1371/journal.pmed.

Bernard Appiah, (2012) Snakebite neglect rampant in Africa. CMAJ. 2012 January 10; 184(1): E27–E28.

Bethwell O Owuor ,Daniel P, Kisangau J. (2006) Kenyan medicinal plants used as antivenin: a comparison of plant usage Ethnobiol Ethnomed. 2006; 2: 7.

Chippaux JP, (2011). Estimate of the burden of snakebites in sub-Saharan Africa: a meta-analytic approach. Toxicon 2011 Mar 15;57(4):586-99. Epub 2011 Jan 9

Coombs MD, Dunachie SJ, Brooker S, et al. (1997). Snake bites in Kenya: a preliminary survey of four areas. Trans R Soc Trop Med Hyg. 1997 May-Jun;91(3):319-21

Ian D. Simpson, Robert L. Norris, (2009) .The Global Snakebite Crisis—A Public Health Issue Misunderstood, Not Neglected: Wilderness and Environmental Medicine, 20, 43 56 (2009)

Kadir, M.F, Karmoker, J.R, Alam, M.R., et al. (2015) "Ethnopharmacological Survey of Medicinal Plants Used by Traditional Healers and Indigenous People in Chittagong Hill Tracts, Bangladesh, for the Treatment of Snakebite". Evidence-Based Complementary and Alternative Medicine 2015: 1–23. doi:10.1155/2015/871675

Kihiko DK. (2013) Venomous snake bite injuries at kitui district hospital. Annals of African surgery. Jan 2013: 10(1) 15-20

Mbindyo, B. S. & Okelo, G. B. A. (1979). Common Venomous Bites and Stings in Kenya. Nairobi: Government of Kenya, The Health Education Division and Audio-Visual Aids Centre

Russell FE, (1990). "When a snake strikes". Emerg Med **22** (12): 33–4, 37–40, 43.

Snow RW, Bronzan R, Roques T, et al. (1994) The prevalence and morbidity of snake bite and treatment-seeking behaviour among a rural Kenyan population. Ann Trop Med Parasitol 88: 665–671.