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E2012-44: Strategies Influencing Achievement in Mathematics and Competence in Soft Skills among Students in Technical Colleges in Kenya

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Abstract

Mathematics is useful in daily life. It plays an important role in developing students' logical, creative and critical reasoning, optimize industrial processes, solve problems, function with linear and non-linear thought processes and communicate solutions briefly and precisely among other soft skills. Despite the critical role played by mathematics, low students' achievement in mathematics and low competence in soft skills had been witnessed. Low achievement and competence in soft skills had been a source of concern to stakeholders in technical and vocational education. That was because the input was not commensurate with the graduate output. Teaching styles in mathematics could be significant in determining the achievement in mathematics and competence in soft skills. Activity-based instructional processes and learning rather than expository means could improve achievement in mathematics and competence in soft skills. Yet, the use of multi-disciplinary approach that depends on using students' experiences in mathematics and science, project-based teaching and industrial-based activities had not been fully exploited in Kenya at least in East and Central Africa. The purpose of the study was to establish what activities in multi-disciplinary approaches could stimulate interest and deepen understanding of concepts in mathematics in technical colleges in Kenya. The findings and recommendations are expected to inform policy decision in establishing quality and relevance in training and accreditation in mathematics in technical colleges in Africa and world over. The study was carried out by a descriptive survey design. Colleges were enlisted using stratified random sampling. Random numbers were used for picking the sample respondents. Lecturer's questionnaire was administered to collect data on teaching styles. The results showed that multi-disciplinary approach with problem-solving in projects involving team-work with industrial staff and small group discussions of case studies in class deepened understanding of mathematics concepts served as the basis for industrial competence in soft skills and on-the job training for employability. The strategy of multi-disciplinary approach for improving students' acheievement in mathematics and competence in soft skills in technical colleges in Africa and world over is recommended.

Key terms*:* Strategies, Students' collaboration, industrial staff, achievement in Mathematics, Competence and soft skills

1.0 Introduction

Mathematics is foundational in scientific, technical, vocational and entrepreneurship training in technical, industrial, vocational and entrepreneurship training (TIVET) institutions in Kenya and world over. It plays an important role in critical thinking, logical thinking, effective decision making, and communication. Learning of mathematics is based on experimental and manipulative activities for competence-based training and assessment (CBTA) as well as competence in soft kills for creative problem-solving, critical thinking and effective decision making(Jackson, 2009; Jackson, Dukerich and Hestenes, 2008). Despite the critical role played by mathematics in daily life, students' achievement in mathematics technical and vocational institutions in Kenya (Bukhala, 2009; Amuka, Olel and Gravenir, 2011; Obengo, 2011) and world over has persistently been low (Absi, et al., 2011; Jackson, 2009 and CRS, 2007).

Students in Kenya and the world over viewed learning of mathematics as mere reproduction of abstract concepts and non-practical applications making the discipline difficult (Absi, et al., 2011 and Khakala, 2009). Hence, low achievement in mathematics has been associated with deficiencies in instructions (Jackson 2009; Khakala, 2009 and Orado, LaTray, & Rozelle, 2011). Dominative teaching and learning approaches observed in institutions of learning has a display of the knowledge and skills of the instructor while students become passive recipients of the mathematical theories, principles, working procedures and algorithms making mathematics learning boring and unfruitful. Activities drawn from familiar surrounding are likely to raise questions in students mind. The process of seeking for answers lead to construction of knowledge. Activity-based learning in multi-disciplinary approaches can develop students' conceptual understanding in mathematics. However multi-disciplinary approaches that incorporate activity-based learning as a source of content and pedagogical strategies for developing students' conceptual understanding in mathematics has not been fully exploited. Hence, the impetus for this study is justified.

In Kenya, the National Council of Science and Technology (NCST) visions is a multi-disciplinary approach in meeting the need for competent-based training and assessment through science, technology, engineering and mathematics (STEM) scholars' development. Similarly, research in

STEM was heralded by Congressional Research Service (CRS) Report (2007) in institutions of learning in USA. STEM was initially responding to students' low achievement in science and mathematics in USA compared to their counterparts from Hong Kong, Singapore, and Chinese Taipei. The research project aimed at equipping students with a competitive edge for the 21st century creative innovations; prepare scientists, technologists, engineers and mathematicians who are globally and strategically placed for technological and scientific advancement. Low achievement in mathematics as well as low competence in Kenya and world over has been has been source of concern to the industries as consumers of scientific and technological knowledge and skills, student, parents/ guardians, instructors, educators, government among other stake holders because the graduates output is not commensurate with investment.

2.0 Literature

The global view of provision of instructions in TIVET in the developed countries such as Britain, Germany, Japan among others is anchored on the advent of: digital simulation for learning in engineering, creative designing, architect, and actuarial science (Zachary, 2009); robot teachers (Gatonye and Mathenge, 2009); mobile phone learning (Nyantino, 2009), and the need for instructional activities that help students to effectively use the physical tools for enjoyment, nurturing social interactive, creative and innovative learning (Zachary, 2009 and Origa, 2000). The industrially upcoming superpowers have an enduring integration of recreation and sports in the TIVET instructions (Sriharikota, 2009 and Shobon, 1978). According to Zachary (2009) digital simulation overemphasis on TIVET instruction with out physical and hands-on activities produce creative and innovative graduates who are not in touch with the physical world.

The achievement of Japan to have modern education for scientific and technological progress promoting industrialization and economic growth faster than her peers such as: former West Germany, Israel, and United States of America (USA) has been associated with practical teaching and learning processes done in real-life situations (Kerre, 2010). Similarly, Shobon (1978) in Social Education Council recommended Practical training that involves students in activities done on the job and group activities in Japan institutions encouraged development of scientific and technological expertise. According to Kombo (2005:135) interactive teaching involving instructional activities:

stimulate intellectual inquiry and the critical thinking skills necessary to serve the needs of the future. Schools events such as academic forums, science congress, seminars, and debates encourage critical thinking in students.

Hence, cooperative learning activities that encourage limitless exchange of ideas among students in the institutions, across institution and academic staff through the use of ICT plat-form can play an important role in developing understanding of mathematics (Kearney, 2010). The use of ICT in teaching and learning play an important role in games and simulations. However, professors in these areas think that too much digital simulations with out students' hands-on activities involving use of physical tools can make them loose touch with the physical world (Zachary, 2009). The concern about lack of hands-on activities and having overuse of digital simulation in American Technical, Industrial, Vocational and Entrepreneurship Training (TIVET) arose as a result of the frustration of engineering, architect and creative design professors who found out that their best students had never taken apart a bicycle or built a model of an airplane (Zachary, 2009). According to the same report, overuse of digital simulation makes creative designers and engineers rebel against their alienation from the physical world.

The study by Kombo 2005:149) suggested that there exists a strong link between the cooperative learning and motivation to be competent by saying that:

the more the students and teachers care about each other, the harder they will work to achieve mutual learning goals. Long-term and persistent efforts to achieve come from the heart not from the head. Individuals seek opportunities to work with those they care about. As caring increases, so do feelings of personal responsibility to do ones share of work, a willingness to take on difficult tasks, motivation and persistent in working toward goal achievement, and a willingness to endure pain and frustration on behalf of the group. All these contribute to group productivity. The success experienced in working together to get the job enhances social competencies, self-esteem and general psychological health.

This means that the more the involvement of students in instructional activities the higher the chances of developing an all round person. The practice of multi-disciplinary approach in science, technology, engineering and mathematics STEM is desired (Earnest, 2009). Mathematics learning based on apprenticeship has been missing in Kenyan technical and vocational institutions. That may call for integration of teaching and learning experiences in Mechanics lessons by actualizing mathematical problems in activities in games and simulations as well as hands-on, minds-on and hearts-on. Activities carried out by students in experiments through improvisation in which the teacher plan for teaching, does the lesson, see and improve **(ASEI/PDSI)** approach as an intervention strategies was proposed to arouse and sustain curiosity and improving students' competencies such as problem solving, analysis, synthesis, and application of relevant information in mathematics and science was used in secondary schools level by Strengthening Mathematics and Science in Secondary Education (SMASSE) (GoK, 2010). Hence, instructional activities play a key role in skills and knowledge acquisition for creative innovation. Hence, the impetus for this study is justified.

Small-groups-based instructional activities play important role in soft skills development (Kombo, 2005; Muthoni, 2012; Muthoni and Origa, 2000).The soft skills includes: critical thinking, psychological health; creative problem-solving; synthesis of knowledge; promoting self-esteem and facilitating teaching of meaningful content. Hence, students' achievement in mathematics can be improved through instructional activities which also develop soft skills. Hence, collaborative learning can also sustain students' motivation in learning Mathematics. This view was reinforced by Kombo (2005: 166) who observed that:

> *cooperative learning promotes creative thinking by increasing the number of ideas, quality of ideas, feelings of stimulation and enjoyment, and originality of expression in creative problem solving.…Cooperative learning in classroom goes beyond just achievement, positive achievement, and psychological health. …It is the keystone to building and maintaining stable marriages, families, careers and friendships… the focus of on learning shifts from the teacher to the student.*

This suggests that involving students in cooperative learning activities also help teachers to shift from over-reliance on text question-and-answer to instructional activities which develop an all-round person and encourage instructors experiment on instructional alternatives. Kombo (2005) and Muthoni (2012) concurred that students' competence motivation can be sustained by encouraging the weak students to collaborate with their peers on instructional tasks that can arouse and maintain curiosity for increased motivation and academic improvement. Similarly, Origa (2000) and Khakala (2009) found that use of concrete objects and activity-based approaches encouraged deeper understanding of Mathematics concepts compared to approaches based on chalk and talk.

Village-centered craft oriented technical training in colleges is desired. This is because the experiences from the informal sector commonly known as *Jua Kali* sector in Kenya contributed to creative innovations. Gatonye (2009) observed that

> *although universities have proven the most prolific in publishing research papers, with 194% growth in the last five years, it is the informal sector which leads in patenting of*

practical innovations. The Permanent Secretary Ministry of Trade and Industry, Prof. Lonyangapuo, said that out of 10 patents registered since 2001, none were from local universities. Out of the 50 expected patents in the next 3 years, he said that most of them would come from Jua Kali sector.

That meant that involvement of students in the informal (Jua-Kali) sector activities can complement provision of instruction in technical colleges and improve students' achievement in mathematics, develop on-the-job soft skills employability skills needed as well as encourage creative innovations. This is because *Jua Kali* perhaps provides greater opportunities for self-employment of the technical college students (Gatonye, 2009). Yet, the area on the role of informal sector as instructional activities for equipping trainees with soft skills had not been fully exploited.

Sustaining students' motive in mechanics goes beyond meeting the physiological needs. That calls for helping the students to identify another reason for pursuit of excellence in mechanics. The study by Gross (1996:97) postulated that:

" the master reinforcer which keeps most of us motivated over a long period of time is the need for a sense of personal competence, defined as our capacity to deal effectively with the environment. It is intrinsically rewarding and satisfying to feel that we are capable human beings to understand, predict, and control our world (a major aim of the study of science). The need for competence is seen to be continuous, ongoing motive. It cannot be satisfied fully. It is satisfied then it appears again because it not rooted in any physiological need" (Gross, 1996:97).

This means that when the desire to be competent is sustained, individuals' productivity in terms of modeling mathematical relations, generating ideas, and problem-solving can be guaranteed. As soon as such individuals accomplish one task the sooner they embark on improving it or creating a new one. Hence, educators of mathematical calculation in mechanics will need to learn to trigger this need so as to sustain students' curiosity that will make them mathematicians for life and researchers. Hence, the impetus for this study is justified.

The need for competence in workers, trainees or students discharging their responsibilities in technologically competitive and intensive market conditions is necessary and urgent. The scores attained in curriculum based assessments in theoretical training is not sufficient evidence of competence without successful completion of On-the-Job-Training (OJT) programs. Competence standards gained by trainees in the workplace include all awareness, knowledge, skills and attitudes which are useful in bridging the gap between curriculums based training, help gain insight into what is provided in the course materials as well as practical training programs Khakala (2009) and

Mustafa (2012). Instructors and their trainees' collaborative activities in industrial settings (Kairu, 2012) as where the instructors are also producers, life-long learners, supervisors, role models of professionalism and partners in developing apprentices is desired.

3.0 Results and Discussion

The results from the questionnaires and interviews were analyzed and reported in a condensed for with agree, unsure or disagree. Table 1 shows the lecturers opinion on the students' achievement in mathematics in technical institutions in Kenya.

Table 1: **Achievement in Mathematics**

A-Agree *U- Unsure* *D- Disagree*

Achievement in mechanics includes:	**A**	**U**	**D**
a) Ability to analyse situations and come up with a hypothesis	62	18	20
b) Make graphical and diagrammatical representations of phenomenon	76	6	18
c) Collect data, organise and analyse data, interpret data make conclusions	69	11	20
d) Form algebraic equations used in problem	57	10	33
e) Provide brief explanations of the mathematical results	30	3	67
f) Ability to work-out problem solving in class exercise	66	14	20
g) Solving problems in real life situations	75	2	23
h) Passing internal and curriculum based examinations in mathematics	96	3	1
Factors found to influence achievement in mathematics includes	**A**	**U**	**D**
a) Students view of mathematics as a mare reproduction of abstract ideas	90	4	6
b) Opportunities for practical applications	56	13	31
c) Qualifications of teaching staff	61	3	36
d) Attitudes towards mathematics	77	3	20
e) Involving students in teaching and learning activities	96	2	2
f) Availability of teaching/learning materials	92	2	10
g) Instructors and trainees industrial-based activities	78	6	16
h) Use of audio-visual resources charts, diagrams, models	95	3	2

The current study findings concurred with what ILO (2010), Kerre (2011), Kerre (2010) and Solomon (2011) asserted that on-the-job and off-the-job activities motivate students to work hard, encourage problem-solving skills development, develop industrial precautions and safety in the work place to protect the internal and the external public critical thinking, modeling mathematical relations and capacity to innovate. Similarly, the findings concurred with what Kerre (2011), Khakala (2009) and Mustafa (2012) asserted that designing systems that are environmental friendly, ability to work with green technology, able to take risks in an enterprise, use of mathematical thought processes to discuss and explain reasoning, use mathematical and numeracy skills to provide evidence for informed decisions, answer questions from assessors. The soft skills needed are also needed in maintenances, repair and operations (MRO) Kerre (2010) as used in the supply chain management. The results in Table 2 shows the lecturers' opinion related to competence in soft skills developed in mathematics in technical institutions.

Table 2**: Competence in Soft Skills**

Development of Competence in soft skills is necessary because:	F %	M %
a) Promote physical and mental wellbeing	78	76
b) Help promote healthy interpersonal relationships and form lasting friendship (psychological health)	89	90
c) Help make informed and effective decisions	76	74
d) Develop full potential	68	72
e) Translate knowledge, attitudes, skills and values into action	73	74

The current study and the work by Kombo (2005), Muthoni (2012) and Origa (2000) agreed that there is need for soft skills development and these soft skills are developed through instructional activities. Kombo (2005) and Muthoni (2012) concurred with the current study that mental well-being, physical well being, interpersonal relationships, effective communication and team workmanship were prioritized in work-place competence.

Table 3 shows the specific soft skills developed through activities in mathematics in technical institutions in Kenya.

Table 3: **Soft Skills developed through Collaborative Activities in Mathematics**

Soft skills include:	**F %**	**M %**
a) Critical and creative thinking skills	60	69
b) Problem solving skills	49	60
c) Coping with stress	59	68
d) Negotiation skills	75	74
e) Entrepreneurship skills	51	49
f) Information handling skills	65	69
g) Effective communication skills	68	65
h) Conflict resolution skills	54	57
i) Assertiveness	45	42
j) Team-work skills	47	53
k) Sales and marketing skills	78	72
l) Ability to engage in community service	65	67
m) Instructional activities can develop soft skills	34	31

The current study and Chaffins (2010) concurred that soft skills include: job readiness skills such as: effective workplace communication; interpersonal skills which include conflict resolution, active listening, negotiations, ethical behavior, getting along with co-workers, assertiveness and managing stress. They also include job search skills such as finding job openings, resume writing, interview skills, and networking and financial management to help trainees manage the money they earns. Similarly, the work by Mustafa (2012) is similar to the current study in that students taking technical and vocational training need to develop specific soft skills such as motivation, reflection, self-evaluation, self-guidance, critical and cross-disciplinary thinking, teamwork and problem-solving skills. The soft skills developed through mathematics include problem-solving, critical thinking, logical thinking (GoK, 2010; Jackson, 2009 and Khakala, 2009). The current study and Mustafa (2012) agreed that the skills developed through mathematics can train people to respond to complex demands, communicate with and understand others, plan ahead, make innovative choices and take risks and accept the consequences. Industrial-based activities develop hard and soft skills (Kerre, 2011). Table 4 shows the students opinion on the influence of instructional activities on students' soft skills development.

Table 4: Influence of instructional activities in mathematics

Influence of instructional activities on students	A	U	D
a) They are more actively involved	72	5	23
b) Students show great interest and responsiveness	87	1	12
c) Attend lessons more punctually and promptly	83	2	15
d) Carry discussion beyond class time	63	2	35
e) Students' interest and curiosity are aroused and sustained	59	12	29
f) Able to relate mathematics to real life experiences	78	11	11
g) Industrial activities can motivate trainees to keep working	93	3	4
h) Encourage team work	72	12	16
i) Provide opportunities to develop key competencies such as problem-solving, analysis, synthesis, and application of relevant information	87	6	7

The report by ILO (2010) concurred with the study findings that most African TIVET institutions have been unable to cope up with technological changes in the workplace and consequently producing graduates that are not suited to the industry. However, the industrial-based activities that involve academic staff and industrial staff and students can reduce the impact of inadequate or limited training facilities. The current study and the work by Kairu (2012) concurred that instructors in industrial attachment work as producers, life-long learners, supervisors, role models of professionalism and partners in developing apprentices. Supervised farming activities like visits to the market by TIVET students can provide students with opportunity to learn data handling techniques that are essential in market information process sing skills and experiences such as customers and clients handling.

4.0 Conclusion and Recommendation

The link between mathematics and soft skills is best illustrated by instructional activities that encourage problem-solving skills development. The activities develop problem- solving if they require creativity, insight, original thinking, imagination and application of the previously learnt knowledge and skills. Problem-solving that is in both mathematics and soft skills involve analyzing the situation, translating the results, illustrating the results, and seeing the alternative solutions. Problem-solving in mathematics is critical in soft skills development because it encourage reflective thinking, continuous monitoring and evaluation through continuous re-learning experiences (CRE). Supervised farm produce related activities like visits to the market by TIVET students can provide students with opportunity to learn data handling techniques, market information processing skills and experiences and customers and clients handling experiences. Games and simulation encourage enterprise orientations and negotiations skills to students. Instructional approaches that encourage on-the-job-training and off-the-job-training activities; activities in the informal sector; games and simulations; small-group discussions and collaboration between students and trainees could post higher scores in mathematics and develop soft skills among TIVET graduates. Competence in soft skills developed through mathematics activities include: critical and creative thinking skills, problem solving skills, coping with stress, negotiation skills, entrepreneurship skills, information handling skills, effective communication skills, conflict resolution skills, assertiveness, team-work skills, sales and marketing skills, ability to engage in community service and instructional activities in mathematics can develop soft skills. The results showed that multi-disciplinary approach with problem-solving in projects with team-work involving academic staff and industrial staff and small group discussions of case studies in class deepened understanding of mathematics concepts served as the basis for industrial competence in soft skills and on-the job training for employability. The strategy of multi-disciplinary approach for improving students' acheievement in mathematics and competence in soft skills in technical colleges in Africa and world over is recommended.

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