ENHANCING STUDENTS' COMPETENCE DEVELOPMENT IN FOUNDRY PRACTICE AT THE DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING, KYAMBOGO UNIVERSITY

NAMUTEBI MADINAH DINAH

17/U/14858/GMVP/PE

A RESEARCH DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER'S DEGREE IN VOCATIONAL PEDAGOGY OF KYAMBOGO UNIVERSITY

SEPTEMBER, 2022

DECLARATION

I, Namutebi M. Dinah do hereby declare that this research dissertation entitled "Enhancing Students' Competence Development in Foundry Practice at the Department of Mechanical and Production Engineering, Kyambogo University is an original document and has not been published or submitted for any award and other material used herein has been duly acknowledged as references.

Namutebi Madinah. Dinah Reg. No. 17/U/GMVP/14858/PE

Signature: ____________ Date: 30/9/2022

APPROVAL

This is to acknowledge that this research dissertation report entitled "Enhancing Students' Competence Development in foundry practice at the Department of Mechanical and Production Engineering, Kyambogo University has been submitted to the Directorate of research and graduate training with the approval of the undersigned research supervisors.

Assoc. Prof. Kato Habib (PhD.)

Department of Agriculture and Production

Kyambogo University

Supervisor	3rd Oct. 2022 Date

Dr Kintu Denis (PhD)

Department of Technical Teacher & Instructor Education

Kyambogo University

Supervisor	28.09.22 Date

DEDICATION

This research dissertation is dedicated to my family especially my husband Mr Ssenyangu Ambrose, Dr Shinyekwa Isaac, Mrs Shinyekwa Evelyn, and to all my children who missed my parental love during my rash hours, and I feel shy to say so but my achievement is for you to get pride and encouragement.

Above all praise be to the Almighty God who has been my last resort when everything seemed difficult.

ACKNOWLEDGEMENT

First and foremost, I thank the Almighty God for the courage and knowledge that he gave me during the study period.

I also acknowledge with gratitude the encouragement received from my lecturers. Special appreciation is extended to Associate Prof. Kato Habib and Dr Kintu Denis for their selfless contribution to the success of this thesis.

I further recognize the immense contributions of my Masters of Vocational Pedagogy, Cohort Seven colleagues.

Further still, I acknowledge the contributions from the staff and management of the Department of Mechanical and Production Engineering for the help they rendered to me during this study and lastly to the year three students that offer foundry technology especially the Bachelor in Mechanical and Manufacturing Engineering class.

TABLE OF CONTENTS

DECLARATION .... **i**

APPROVAL .... **ii**

DEDICATION .... **iii**

ACKNOWLEDGEMENT .... **iv**

TABLE OF CONTENTS .... **v**

LIST OF TABLES .... **ix**

LIST OF FIGURES .... **x**

LIST OF ABBREVIATIONS .... **xi**

LIST OF APPENDICES .... **xii**

ABSTRACT .... **xiii**

CHAPTER ONE: INTRODUCTION **1**

1.1 Background to the study 1

1.2 Motivation statement 12

1.4 Purpose of study 14

1.5 Specific objectives of the study 14

1.6 Research questions 14

1.7 Significance of the study 15

1.8 Scope of the study 16

1.9 Definition of key terms 16

CHAPTER TWO: LITERATURE REVIEW **19**

2.1 Foundry practice and its relevance. 19

2.2 Hands-on training... 25

2.3 Theory informing the study 26

2.4 Gaps hindering students' competence development in foundry practice at DMPE 30

2.5 Interventions to improve students' competence development................................ 30

2.6 Evaluate the implemented interventions to enhance students' competence development.. 34

2.7 Researcher's summary of literature review 34

CHAPTER THREE: METHODOLOGY.. 35

3.1 Action Research 35

3.2 Research design and approach 36

3.3 Location of the Study.. 37

3.4 Study Population... 37

3.5 Sampling method 38

3.6 Data collection method and tools... 39

3.7 Data collection tools.. 42

3.8 Research process 44

3.9 Data analysis 44

3.10 Ethical consideration.. 45

3.11 Validity of data... 45

3.12: Reliability of Instruments 46

CHAPTER FOUR: ACTION IMPLEMENTATION, RESULTS AND EVALUATION 47

4.1 Hindrances to students' competence development in foundry practice at DMPE ... 47

4.2. Interventions that enhance students' competence development. 48

4.3 Implementation of the identified interventions to enhance competence development in foundry practice at DMPE 50

4.4 Evaluation of the implemented strategies 61

4.5 Discussion of results 72

4.5.1 Gaps hindering students' competence development in foundry practice at DMPE 72

CHAPTER FIVE: SUMMARY, CONCLUSIONS, RECOMMENDATIONS 78

5.1 Summary 78

5.2 Conclusion 79

5.3. Recommendations 80

REFERENCES 83

APPENDICES 95

Appendix 1: Letter of Introduction to DMPE 95

Appendix II: Future workshop carried out at DMPE staffroom 96

Appendix III: Attendance list for future workshop 96

Appendix IV: Pairwise ranking process and results 97

Appendix V: Action plan for the identified strategies. 97

Appendix VI: Introduction letter to DMPE from NOMA seeking permission to 98

Appendix VII: Students carrying out pattern making processes during the 99

Appendix VIII: Evaluation stage 100

Appendix IX: Attendance lists during evaluation meetings...................................... 101

Appendix X: Maintenance plan 102

Appendix XI: Machine History Cards 104

Appendix XII: Research tools used in the study 106

Appendix XIII: Focus Group Discussion Guide 108

Appendix XIV: Action Research Evaluation Tool of Enhancing 109

Appendix XIII: Assessed pattern draft 113

Appendix XIV: Patterns made by students 113

Appendix XV: Students making the presentation of patterns 114

LIST OF TABLES

Table 1: Weighting in Foundry Technology 7

Table 2: Showing actionable points. 11

Table 3: Summary of Results from Pair Wise Matrix. 12

Table 4: Study population 41

Table 5: Summary of methods and tools used in study ………………………………… 46

Table 6: Implementation of the interventions to enhance competence development. 56

Table 7: Increase in practical time per week from the rescheduling of the practical session. 58

Table 8: Results from the evaluation tool on benefits of rescheduling practical time … 68

Table 9: Results from the evaluation tool on benefits of space and equipment availability …………..…... 69

Table 10: Results from the Evaluation tool on benefits of the use of group learning for more hands-on activities. 71

Table 11: Results from the evaluation of benefits of Advocating for Accessibility of DMPE workshops to real-life activities brought by the communities 72

Table 12: Summary of analytic ratings of the implemented strategies. 73

Table 13: Results of the assessed groups 76

LIST OF FIGURES

Figure 1: Participants during a future workshop meeting

Figure 2: Flow diagram of casting production

Figure 3: Core components of situated learning theory

Figure 4: Authentic Contexts

Figure 5: Sequences of action-reflection cycles

Figure 6: Revised timetable with rescheduled foundry technology practical sessions

Figure 7: Before organizing the DMPE foundry workshop

Figure 8: After organizing the DMPE foundry workshop.

Figure 9: Students participating in the pattern-making process at the carpentry workshop, DCBE.

Figure 10: Students melting metal at DMPE foundry workshop.

Figure 11: Students working in groups on core making

Figure 12: Students are guided by the technician as they worked on the clients' work.

Figure 13: Students, Technicians, and the Researcher during a rework on insignia (client's work).

Figure 14: Evaluation meeting.

Figure 15: One group presenting their pattern to technicians.

LIST OF ABBREVIATIONS

ADB	African Development Bank
AR	Action Research
BTVET	Business Technical Vocational Education and Training
BIEM	Bachelor in Industrial Engineering and Management
BEMME	Bachelor in Engineering Mechanical and Manufacturing Engineering
CH	Contact Hour
DMPE	Department of Mechanical and Production Engineering
FGD	Focus Group Discussion
FW	Future Workshop
GDP	Gross Domestic Product
ICT	Information Communication Technology
KYU	Kyambogo University
MoES	Ministry of Education and Sports
MVP	Masters of Vocational Pedagogy
PAR	Participatory Action Research
TVET	Technical Vocational Education and Training
VET	Vocational Education and Training
UIRI	Uganda Industrial Research Institute
UNBS	Uganda National Bureau of Standards
UNESCO	United Nations Education, Scientific and Cultural Organization

LIST OF APPENDICES

Appendix I: Introduction letter to DMPE from NOMA seeking permission to carry out Action Research

Appendix II: Future workshop carried out at DMPE staffroom.

Appendix III: Attendance list for a future workshop

Appendix IV: Pairwise ranking process and results

Appendix V: An action plan for the identified strategies.

Appendix VI: Introduction letter to DCBE from DMPE seeking permission to carry out Action Research

Appendix VII: Students carrying out pattern-making processes during the implementation stage

Appendix VIII: Evaluation stage

Appendix IX: Attendance lists during evaluation meetings.

Appendix X: Maintenance plan

Appendix XI: Machine History Cards

Appendix XII: Research tools used in the study

Appendix XIII: Presentation of patterns by students

Appendix XIV: Patterns made by students

Appendix XV: Assessed pattern draft

ABSTRACT

The study aimed to explore strategies for enhancing students' competence development in foundry practice at the Department of Mechanical and Production Engineering (DMPE), Kyambogo University. The study was premised on the theory of participation and reflections that guarantee competence development in foundry work. The study was guided by four specific objectives; examine gaps hindering students' competence development in foundry practice, identify interventions, implement the identified interventions and lastly evaluate the implemented interventions aimed at enhancing students' competence development in foundry practice at DMPE. A Participatory Action Research (PAR) design was used to carry out the study using qualitative methods of descriptive data collection that included; work process analysis, Focus Group Discussions (FGDs), future workshops, interviews, observation, and documentary analysis. The purposive sampling technique was used to select the respondents who included DMPE administrators, foundry technology teaching staff, and students. The analysis of the process of teaching foundry technology practical work revealed more emphasis on theory than practice inappropriate method of assessment, and inadequate training facilities and equipment, as the most significant gaps that needed to be addressed. To address the gaps, the following intervention strategies were used: Group learning method and advocating for accessibility to the DMPE workshop. The evaluation findings of this study revealed that group learning enabled students to acquire confidence and immediate feedback in foundry practice. In conclusion, active participation in foundry practical work through trying and failing and trying again increases students' competencies. Recommendations are that display boards should be constructed to display sound patterns in addition to using small manageable groups during practical sessions and assessing the foundry process rather than the final product.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

The background of this study focuses on; foundry practice and Vocational Pedagogy as a field of study in Vocational education.

Sharma (2001) defines foundry practice [1] as; with a few exceptions, the first step in manufacturing metallic components. Metal casting as a manufacturing process involves operations such as; pattern-making, sand preparation, moulding, melting of metal, pouring in moulds, cooling, shaking out, fettling, heat treatment finishing and inspection (Anaele & Ogundu, 2020). Additionally, Foundry practice is the knowledge generated through hands-on experience in pouring molten metal into the desired cavity (created using a pattern) and allowed to solidify to manufacture castings such as industrial machinery, farm and automotive equipment (Anaele & Ogundu, 2020).

According to Clinton, Godstime, and Chukuladi. (2022), over-dependence on imported spare parts and machine components is partly due to little enterprise in the foundry industry. Additionally, the foundry craft practice skills for the entire metal casting process are very substantial in response to equipping students with relevant skills and technical competencies (Clinton, Godstime & Chukuladi. 2022).

In Uganda, it's believed that manufacturing is the only way a developing can create more decent well-paying jobs for its young and growing population (Guma & Ogobi 2019). Dick Kamugasha, Director of Technology Development Centre pointed out that the Uganda Industrial Research Institute (UIRI) is set to fabricate more complex machinery following the establishment of foundry technology. Additionally, His Excellence Yoweri Kaguta Museveni

[1] Term Foundry practice is used interchangeably with metal casting (Campbell,2015).

envisioned the advancement of technical skilling in Uganda, bridging the gap in the labour market during the commissioning of the skills development facility at Namanve (Wasswa, 2020) in the second opinion paper of January 16th 2020. Furthermore, the Government of Uganda has valued foundry practice by including it in courses such as; the National Certificate in Welding and Fabrication (NCWF), Metal Fabrication (NCMF), National Diploma in Mechanical Engineering (NDME) and Higher Diploma in Mechanical Engineering (HDME) courses (Ministry of Education and Sports, 2015).

At Kyambogo University, foundry practice is guided by Uganda's Vision 2040 which aims to transform Ugandan low-income society to an upper middle-income country by 2040 (Uganda Government, 2013). Foundry technology is one of the core courses at the Department of Mechanical and Production Engineering at Kyambogo University, which is taught in different programs, namely; Bachelor of Engineering in Mechanical and Manufacturing Engineering (BEMME), Bachelor of Engineering in Automotive and Power Engineering (BEAPE), Bachelor of Engineering in Environmental Management Engineering (BEEEM), Bachelor of Industrial and Management Engineering (BIEM) and Diploma programs for instance; Ordinary Diploma in Mechanical Engineering (ODM), Diploma in Refrigeration and Air conditioning Engineering (DRAE) and Diploma in Automotive and Power Engineering (DAE). Students in the Department of Mechanical and Production Engineering, Kyambogo University produce articles that range from; brass solid and hollow shafts, pulley blanks, aluminium candle moulds and chalk moulds.

Equipping institutions with equipment by African Development Bank (ADB) is yet another development in technical institutions where the Department of Mechanical and Production Engineering foundry shop has changed its state of art. Furthermore, challenges such as collaboration with research institutes and availing equipment in Technical

Vocational Education Training (TVET) institutions have been catered for (African Development Bank report, 2020).

Despite the above developments, Kyambogo University which offers TVET, particularly in Mechanical Engineering Department is still faced with several challenges that depict low graduate competencies in the world of work (Titeca, 2019). The challenges pointed out by stakeholders during work process analysis discussions include; rapid technological advancement, low productivity of students in hands-on training; lack of proper maintenance schedules of foundry equipment; fear of safety-related foundry hazards and inaccessibility of the foundry shop by the community with real-life activities. Without a doubt, the above challenges are depicted in the learning outcome on the side of the foundry students who are queried in the world of foundry practice (Titeca, 2019). The Uganda Country report (2014) mentioned that the Uganda National Bureau of Standards (UNBS) provides hands-on training to new employees in the use of technology on which the organisation's laboratories rely to conduct tests for the industries in the country.

Therefore, this area of concern was the basis of the study where several interventions were identified by stakeholders to address the challenges. In addition, possible solutions to the challenges associated with competencies development in foundry practice at the DMPE were established. To that effect, the researcher sought to find out the objectives of the department which were; to equip engineers with theoretical and practical technical skills to enhance the sustainability of small large-scale industries; carry out research, design products and modifications to a large number of engineering activities within manufacturing industry; instil into engineers technological and managerial skills required for self-employment and problem solving; produce engineers who are equipped with health and safety regulations for cleaner production; and train people in advanced higher education, research and development

(Kyambogo University, 2015). In addition, the objectives of the TIEM 3105 [2] course in the department were; investment casting as a process of achieving dimensional accuracy and high-quality surface finish using wax patterns; the procedure of manufacturing patterns, which requires specialized instructions notably vocational pedagogy to achieve the desired learning outcome.

1.1.1 Vocational pedagogy as a field of study in Vocational Education

Lucas, Spencer and Claxton (2012), define pedagogy as "the active participation of students in the teaching process, planning and designing of the learning conditions". Similarly, Muganga and Ssenkusu, (2019) broadly define pedagogy as multiplicity in planned and designed teaching approaches that allow active participation and reflections of students in various vocations such as foundry practice. This brings to the researcher's attention the term pedagogy regarding foundry practice as the art of allowing students to actively participate in the creativity and development of knowledge and skills needed in the foundry field.

According to Lucas (2014), vocational pedagogy is the science, inspiration and expertise of teaching and learning vocational education. Therefore, the researcher deduces that vocational pedagogy is a science that deals with facts guided by learning theories and art since one has to be creative. Foundry technology as a practice requires artisans that are creative as they design different engineering components. However, the principle of metal casting should guide the manufacturing process while considering safety first.

According to Lucas et al (2012), vocational pedagogy is the totality of the decisions and approaches used by vocational technicians to meet the needs of students in the context of the teaching and learning process. Similarly, vocational pedagogy focuses on developing models

[2] TIEM 3105 Course code for foundry technology as a course unit done in year3 semester I.

and tools used in vocational education and training for effective teaching that emphasize the learning outcome ((Lucas, 2014).

Hence, Masters in Vocational Pedagogy (MVP) program at Kyambogo University is of great relevance in terms of promoting hands-on training and the production of qualified technicians that aid students' acquisition of the competencies needed to join the world of foundry practice and to continue with their education as well. MVP consists of education focused on teaching, training and learning in technical and vocational education as detailed in specific trades and occupations. The programme focuses on the development of competencies needed at workplaces through one contact hour per week for 15 weeks of teaching with more emphasis on presentations of individual work experiences and group projects. (Arinaitwe, 2021).

The MVP programme was designed to allow the acquisition of general knowledge, theory, and practical training demanded by the labour market at both educational institutions and workplaces (Mjelde, 2017). The programme requires course participants to sustainably execute experience-oriented tasks and problem-based learning activities generated from their field of attachment, in addition to creativity, participation in groups and teamwork (Arinaitwe, 2021).

The core of the learning processes in Vocational Pedagogy is skills acquisition through active participation in group work and continuously strive for perfection (Mjelde, 2006). In addition, vocational pedagogy empowers technicians particularly to enhance learner-centred approaches to hands-on training in foundry practice, for instance, learner-centred internal networking, and small group learning (Mjelde & Daly, 2012). Through such approaches as used in the Master's degree of vocational pedagogy programme, enhanced competencies are seen at the training level, as well as in the workplace. To establish the actualization of approaches in workplaces the researcher conducted a situation analysis at Kyambogo University, Department of Mechanical and Production Engineering (DMPE).

1.1.2 Situation analysis at DMPE, Kyambogo University

Situation analysis is a systematic process of decision-making about prioritising resources for organizational improvement (Witkin & Altschuld, 1995). Foundry technology as a course unit with 4 Credit Units (CU) is taught in year three semester one based on two guiding principles; it is a process and also has advantages as compared to other manufacturing processes to produce students who can explain the procedure for pattern manufacture, perform casting operations with ease and can also create jobs for the community.

Foundry technology is regarded as an informal TVET skill yet it drives most manufacturing processes in Uganda (Kintu & Ahaisibwe, 2019). This could have been due to the informal techniques of training offered by experienced craftsmen, and women in preparation and trades such as auto mechanics, foundry, dressmaking, and cosmetics (Atchoarena & Dullec, 2001) cited in (Oketch, 2014). In this study, a situation analysis was carried out to determine areas for improvement in foundry practical sessions in the course unit; foundry technology (TIEM3105) particularly in enhancing students' competencies for the world of work. The situation analysis was carried out using work process analysis and future workshop procedures.

A step-by-step work process analysis procedure, as advocated for by Sannerud, (2019) was used to analyze the teaching and assessment of foundry practice. Work process analysis involved studying the 2015 revised course structure for TIEM 3105 foundry technology, which provided guiding information on how TIEM 3105 is taught, and assessed and an indication of learning outcomes in terms of competencies. Learning outcomes in TIEM 3105 are acquired through lectures, tutorials, and practical work with the assessment mode indicating 5% Assignment, 10% Test, 25% Practical work and 60% examination.

Table 1: Weighting in Foundry Technology

SN	Unit	Lecture Hours	Practical Hours	Contact Hours	Credit Unit
	TIEM 3105	30	60	60	4

***Source: primary data*.**

Table 1 shows that during delivery, foundry technology theory takes 30 lecture hours equivalent to 30 contact hours while practical takes 60 practical hours equivalent to 30 contact hours, thus indicating a total of 60 contact hours. The course is weighted in credit units considering 15 weeks of teaching in a semester as follows; one credit unit is equivalent to 15 Contact Hours (CH) or one contact hour for 15 weeks of teaching (1 contact hour is equal to 1 Lecture Hour, LH). Furthermore, two practical hours are equivalent to 1 lecture hour as shown in Table 1. Therefore, there was a clear indicator that theory and practice are equally valued in the building of knowledge and competencies in foundry technology.

Further still, Focus Group Discussion (FGD) was employed. FGD involves dialogue between the researcher and respondents to offer insights into what people think and provide in-depth knowledge of the topic under study (Mishra, 2016). In this study, the unstructured interview method was used in focus group discussions to determine gaps hindering students' competence development in foundry practice. Unstructured interviews aim at recognizing participants' feelings and views regarding the study (Creswell, 2014).

In this study the participants in the discussions included; students, technicians, administrators, and lecturers who were willing to participate and with foundry practice knowledge. The researcher mediated the discussions with a key guiding question agreed upon by all stakeholders "why do students fail to competently accomplish tasks despite hands-on training in foundry technology? This followed the listing of stages of preparing foundry graduates that enable competence development. These included*; practical sessions- planning (preparation), delivery (content) / training, assessment. industrial training, scouting, placement, orientation, training, and assessment.*

Gaps were identified at each of the above stages through brainstorming and were clustered as follows; *rapid technology advancement, negative attitude of students and technicians towards practical work, more emphasis on theory than practice, lack of safety guidelines, inadequate time allocated for practical work on the time table, inappropriate assessment technique (assessment of product instead of processes), low students' participation in foundry practical work, inadequate training facilities and equipment.* The pairwise ranking was used and together with stakeholders, we selected the most pressing challenge which was unanimously agreed upon as more emphasis on theory than practice while teaching students of foundry practice at the Department of Mechanical and Production Engineering. This was the basis of conducting a Future Workshop (FW).

A future workshop is a brainstorming technique used in decision-making processes that embrace everyone's idea (Jungk & Müllert, 1987) cited in (Vavoula & Sharples, 2007).

According to Vidal (2006), the future workshop consists of; an organized brainstorming session that emphasizes on prevailing challenges in an organisation (critique phase); a session where participants envisage a future free of the identified challenges (fantasy phase) and an implementation phase where the group discusses the viability of the vision from the fantasy phase and develops an action plan for the implementation of the feasible actions.

In this study, a future workshop was held on 19th February 2019 with 39 stakeholder participants that included Masters in Vocational Pedagogy (MVP) students, staff and students from the Department of Mechanical and Production Engineering as shown in Figure 1.

Figure 1: Participants during a future workshop meeting Source: Primary data, DMPE, 19th February 2019.

Organization of the future workshop at DMPE Staff room on 19th February 2019 was as follows; the theme was brought forward from the work process analysis, permission was sought from the Head of Department, DMPE, invitation of stakeholders, venue and workshop facilities were organized.

The future workshop was conducted for seven hours with a break of one hour for reflection. The workshop was carried out from the staffroom between 9:00 am - 4:00 pm. The area of concern under discussion was "why is there more emphasis on theory than in foundry practical work at the DMPE?" This was presented by the researcher after a word of prayer, opening remarks and stating the ground rules that guided the workshop, which included; ensuring a democratic discussion process, and all ideas being relevant to the study, among others. This was done to establish causes and solutions to the concern through brainstorming. The causes of more emphasis on theory than practice at the DMPE were turned into positive in the fantasy phase, clustered in the idea store, and a feasible solution declared with an action plan.

Critique phase: A critical question was posed to participants, 'What do you believe to be the causes of more emphasis on theory than practice in foundry practice at DMPE? Through brainstorming, participants gave their responses that included; a *large number of students enrolled per programme; inadequate time allocated for practical work on the BEMME timetable; inadequate training material allocation in the university budget; delayed delivery of training materials for a given semester; lack of proper maintenance schedules of foundry equipment; fear of safety-related foundry hazards; inaccessibility to the DMPE workshop to carry out real-life activities brought by the communities; less awareness of the relevance of practical training.*

Fantasy Phase; causes were turned positive and taken in the utopian stage (ideal world) to find how each of the positive ideas would be achieved in the idea stores. These included; a *fewer number of students enrolled per programme; adequate time allocated for foundry practical work on the BEMME timetable adequate training materials allocation in the university budget; timely delivery of training materials for a given semester; proper maintenance schedules of foundry equipment; encouragement of safety practices; accessibility to DMPE workshop to carry out real-life activities brought by the communities; more awareness of the relevance of practical training.*

Through brainstorming ideas were generated on how to achieve the ideal world these were then clustered into nine actionable points; short term (ST), medium term (MT), long term (LT) and the most feasible ideas were identified through a pairwise ranking matrix as seen in (Appendix IV). The actionable ideas are shown in Table 2.

Table 2: Showing actionable points.

SN.	Actionable points	Period
1	Enrol fewer students per programme	LT
2	Allocate more time for practical work by adjusting the timetable	ST
3	Provide adequate training materials in the university budget	LT
4	Enhance students' participation in foundry practical work	ST
5	Generate maintenance schedules for foundry equipment	ST
6	Encourage safety practices	ST
7	Advocate for accessibility to the DMPE workshop to carry out real-life activities brought by the communities	ST
8	Promote more awareness of the relevance of practical work	MT
9	Advocate for timely delivery of training materials	MT

Source: Primary data (2021)

Through pairwise matrix ranking, enhancing students' participation in foundry practical work was noted to be the most feasible action for improving the concern of more emphasis on theory than practice in teaching foundry practice at DMPE.

The pairwise ranking matrix was organized as follows;

A - Generate maintenance schedules for foundry equipment

B - Allocate more time for practical work by adjusting the timetable

C - Advocate for accessibility to the DMPE workshop to carry out real-life activities brought by the communities

D - Encourage safety practices in the foundry workshop. **E** - Enhance students' participation in foundry practical work The results of the pairwise ranking are summarized in **Table 3**.

Table 3: Summary of Results from Pairwise Matrix.

SNo.	Short Term Feasible Action	Results
A	Generate maintenance schedules for foundry equipment	33
B	Allocation of more time for practical work on the timetable.	05
C	Advocate for accessibility to the DMPE workshop to carry out real-life activities brought by the communities	38
D	Encourage safety practices in the foundry workshop.	36
E	Enhance students' participation in foundry practical work	48

Source: Primary data

Stakeholders identified strategies to facilitate in implementation of feasible interventions and developed an action plan that indicated the role of the participants in the study (See **Appendix V**).

1.2 Motivation statement

The researcher is a trainer in formal, non-formal and informal Technical Vocational Education and Training (TVET) educational subsector, who over time observed that students have less attitude towards foundry practice. At Kyambogo University, the researcher observed that students carry out practical work beyond the two hours allocated on the timetable. Furthermore, through individual interaction with students, the researcher established that students' loss of motivation was due to the large number of students that crowd around the technician during a demonstration. This forces the technician to use more theory than practice in addition to faulty and inadequate equipment that limits diversity in foundry process activities.

Personal development in master in vocational pedagogy being at the apex of the career offers multiple opportunities for change in the researcher's teaching techniques from imitation but rather considering scientific understanding of learning theories that inform practical foundry work. Appreciating Information Communication Technology (ICT) has created change and shown the researcher the relevance of self-directed studies while situated learning has motivated the researcher to teach students to try as many times as possible till perfection is noticed. As Lucas, et al. (2012) points out;

''Technicians strive for excellence not only in the prizes from training students but also in the intrinsic gratification from the performance of what they feel is treasured. Lucas, et al (2012) further suggest that intrinsically worthwhile goods and services are of good quality and possess attributes such as; the requirement of a high degree of skill, accountability, teamwork, fidelity and sovereignty" (Winch, 2004, p. 78) as cited in (Lucas, et al., 2012).

The researcher strongly believes that this study conducted using an action research approach, brought about pedagogical skills satisfaction, especially in teaching methods used on large numbers of students in the department.

1.3 Statement of the Problem

Hands-on training in foundry technology results in skills development among students due to the diverse real-life experiences that empower them with technical skills (competencies). Whereas foundry technicians at the DMPE can ably conduct practical work and have a curriculum that balances practical work and theory, through brainstorming sessions in the future workshop, more emphasis on theory than practice was identified as the major challenge that has impeded a successful functional skill acquisition. This has led to the preparation of graduates who are not competent enough in the world of foundry practice due to inadequate students' participation in practical work. To bridge the existing gap, this study was conducted together with the stakeholders to explore strategies for enhancing students' competence development in foundry practice.

1.4 Purpose of study

The study aimed to explore strategies for enhancing students' competence development in foundry practice at the Department of Mechanical and Production Engineering, Kyambogo University.

1.5 Specific objectives of the study

i. To examine gaps hindering students' competence development in foundry practice at DMPE.
ii. To identify interventions aimed at enhancing students' competence development in foundry practice at DMPE.
iii. To implement the identified interventions aimed at enhancing students' competence development in foundry practice at DMPE.
iv. To evaluate the impact of the implemented interventions aimed at enhancing students' competence development in foundry practice at DMPE.

1.6 Research questions

Based on the research objectives, research questions were developed as follows;

i. What gaps are hindering students' competence development in foundry practice at the DMPE?
ii. What interventions can be taken by students and staff to address the gaps in students' competence development in foundry practice at DMPE?
iii. How can the identified interventions be implemented to enhance students' competence development in foundry practice? iv. What are the results of the implemented interventions aimed at enhancing students' competence development in foundry practice?

1.7 Significance of the study

Through increased participation in foundry practice especially in pattern making, students will be motivated to bring close the real-world activities hence being empowered with the required competencies. Similarly, the researcher and foundry technicians will benefit by striving for continuous development as facilitators and practitioners Below are some of the benefits of the study to the researcher, students, foundry technicians and administrators.

The study will enable the researcher and her fellow foundry practice technicians to improve the way they perceive the pedagogical approaches used to train large numbers of students by critically reflecting on the learning theories that enhance students' competence development such as participation and reflection concepts in the pedagogical model of learning by group dynamics.

The students will benefit from this action research through increased involvement in hands-on training. The students will work in small manageable groups of five to seven members which will make them actively participate and make presentations for competence evaluation.

The results of this study will promote cooperation among staff by motivating them to continuously strive for professional growth as stressed by OCED (2009) that teamwork generates prospects for social and emotional support among technicians in addition to the exchange of theoretical knowledge and practical expertise.

Furthermore, the study will act as a source of information in guiding the administrators at DMPE in designing and planning for foundry technology students, especially for space and equipment availability. Finally, the findings to the study will be used by the government to fulfil its plan of advancing from peasant and low-income levels to middle-income levels.

1.8 Scope of the study

The scope of this study is presented under the content scope, geographical scope and time scope.

1.8.1 Content Scope

The study was limited to examining gaps hindering students' competence development, identification of interventions to the gaps, implementing identified interventions and lastly evaluating the impact of the implemented interventions aimed at enhancing students' competence development in foundry practice at the DMPE, Kyambogo University. Emphasis was on pattern making due to its relevance in the casting process and when mishandled defective castings are produced.

1.8.2 Geographical Scope

The study was conducted at the Department of Mechanical and Production Engineering, Kyambogo University, Kampala district in Uganda. The geographical area was dictated upon by the action research that required one to create change in a societal group and the area of study was convenient in the implementation and follow-up process in the study. In addition, the researcher worked hand-in-hand with the Department of Civil and Building Engineering for the implementation of identified strategies.

1.8.3 Time Scope

The study was conducted for a period from February 2019 to December 2021 since the research was cyclic in nature and required additional time to carry out the evaluation process and follow-up.

1.9 Definition of key terms

The following terms were used in the context of the study as follows:

Knowledge: Facts, principles, awareness and understandings of specific realistic situations.

Learning: Life-long change in knowledge, behaviours, skills and attitudes depending on the environment or set goals.

Training: Training is a systematic way of transferring knowledge, skills and attitude for competence development in the foundry as a vocation. Training requires active participation in work and the results motivate the students.

Hands-on training: Use of limited resources to systematically develop the knowledge, attitudes and skills required for a person to be able to perform adequately a job or a task and convert the output into monetary terms.

Competence: Ability, skill, technique and knowledge that foundry practice students acquire to produce defect-free castings.

Foundry: A production factory where ferrous metals such as steel and nonferrous metals such as aluminium and brass are melted and poured into the desired mould cavity to form castings.

Foundry practice: The knowledge generated through hands-on experience in the melting of metal and pouring it into the desired cavity (created using a pattern) and allowing it to solidify followed by inspection and fettling ending up with sound casting. Training in foundry practice requires active participation in work and the results motivate the students which in turn reduces hazards.

Physical facilities: These include; lecture rooms, foundry workshop, furnaces, foundry Moulding tools for instance; slicks, pattern-making machines and hand tools such as flat saws, circular saws, mortisers, lathe machines, turning chisels and measuring tools.

Productivity: Productivity measures are expressed as ratios of certain output to input. Productivity in moulding equals the number of moulds produced per the number of moulding shop workers, which can be improved through; better moulding processes, better safety measures and improved training of workers (Srinivasan, 2012).

Student productivity: In terms of the pattern-making process, is the ratio of the number of patterns produced to the number of groups of pattern-making students. It is measured based on pattern attributes such as surface finish, dimensional accuracy and change in the cross-sectional area through measurement and visual examination.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents related literature on how to enhance students' competence development in foundry practice. The review of other researchers, academicians and scholars' work is guided by the following sub-themes:- i) Foundry practice and its relevance; ii) Hands-on training, Technical vocational education and training and foundry practice; iii) Theory informing the study; iv) Gaps hindering students' competence development; v) Interventions to enhance students' competence development; vi) Implementations of interventions to enhance students' competence development; vii) Evaluation of interventions, and viii) Researcher's summary of literature review.

2.1 Foundry practice and its relevance.

"Tell me and I forget, teach me and I may remember, involve me and I learn," said Benjamin Franklin, was a great scientist, inventor and statesman (Khandelwal1, Ravi1 and Dipankar, 2014 pg. 11). Khandelwall et al (2014) concur by mentioning that it is difficult to learn the art, science and technology of metal casting from textbooks or blackboards. This implies that hands-on training that leads to students' competence development is essential in foundry practice.

The art of metal casting was practised in ancient India and China where moulds were made of stone clay (Beerley, 2001). Beerley 2001 further mentions that foundry practice grew into a craft in the 13th century when the early foundry men in Europe were casting church bells by loam moulding using sweep moulds and the first cannon was cast in bronze in 1313 by a monk in Ghent. Italians at the time of Cellini started making statues using the lost wax (investment casting) process (Beerly, 2001). According to Srinivasan (2000), in the nineteenth century, many developments took place such as; Asa 1847 developed the annealing process for chilled car wheels used for railway caches and freight cars. Seth Boyden in Newark, New Jersey invented the process for the black heart American malleable iron. Around 1950 ductile iron was developed by the international Nickel Company, USA, and the British Cast Iron Research Association as a new cast material (Srinivasan, 2000).

Manufacturing engineering is a study of the processes required to make machine parts and assemble them into machines and mechanisms (Jain, 2001). Sharma (2001) similarly, pointed out that manufacturing processes are grouped into primary and secondary. Primary manufacturing processes involve the first breakdown of material into shapes that are further processed into the final product. For example, casting, forging, extrusion, powder metallurgy and plastic technology. Sharma (2001) further argues that products from primary processes do not need further processing for size, and shapes such as forging, precision casting and powder metallurgy. On the other hand, secondary manufacturing produces products from primary processes and changes their shape and characteristics to either semifinished or finished stage. For example, metal removal processes, and metal forming processes (Srinivasan, 2000). According to Srinivasan (2000 pg. 23) “The shortest distance between raw material and finished part is by casting.’’ Srinivasan further argues that the statement acquired meaning with the progress of deeper scientific knowledge of melting and solidification of metals, casting design and development of newer materials.

Metal casting was viewed as art (Beerly, 2001). Beerly, (2001) further points out that this interpretation persisted until well into the twentieth century. Similarly, Sharma (2001) asserts that casting of metal seems to be one of the most ancient processes of manufacturing metallic components. Sharma (2001) explains casting as; the process of using patterns to create mould cavities of either well-prepared sand or other materials where molten metal is poured, cooled, shaken out, fettled, heat treated, finished and inspected (Sharma, 2001). The solidified piece of metal which is taken from the mould is what is called a casting (Rao, 2004). The production process of castings is shown in Figure 2.

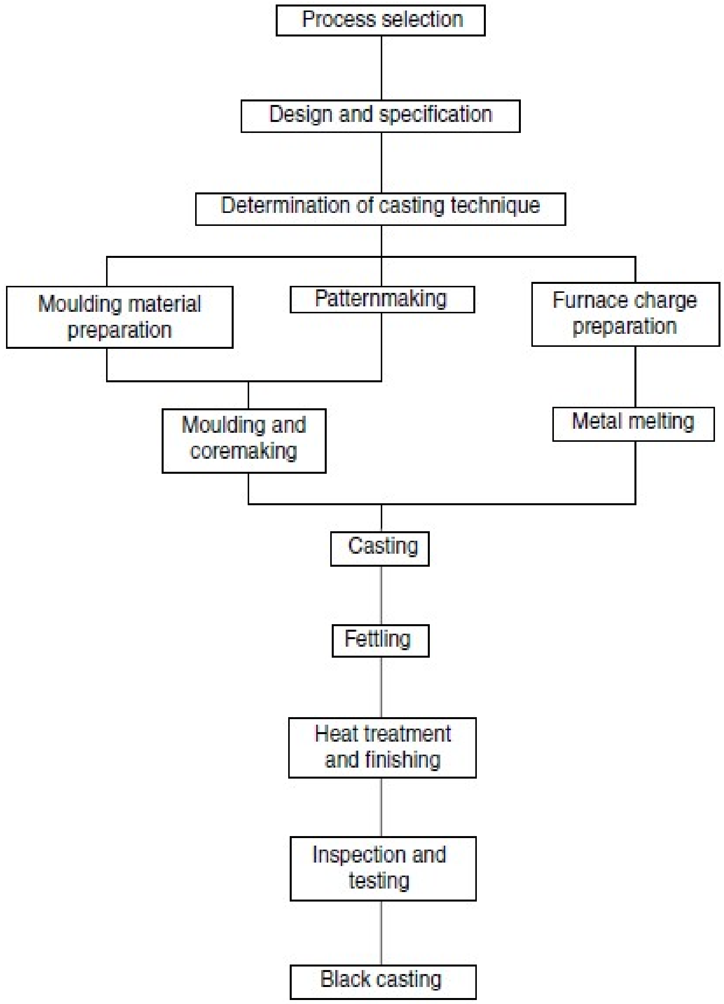


Figure 2: Flow diagram of casting production

Source: Beerley (2001, Pg.23)

The casting process has numerous advantages over other manufacturing processes such as rolling, forging, welding, powder metallurgy, machining and pressing. These include; casting is the most versatile form of a mechanical process for producing components; different shapes sizes and intricate articles can be produced by casting for example watch cases with low grams; it offers one of the cheapest methods and gives high strength and rigidity even to intricate parts which are difficult to produce by other methods of manufacturing such as cylinder blocks and valve bodies. This means that casting can form any shape in one operation eliminating joints and the production of precise castings in metals which are difficult to machine to size is possible.

Brittle metals for example cast iron which cannot be formed by processes such as forging can easily be formed (Jain, 2001; Rao, 2004).

Villar et al, (2012) noted that the metal casting industry produces components used by most manufacturing industries. These include components such as motor vehicle parts, defence equipment, power generation equipment, industrial machinery and construction materials (Jain, 2001). However, due to the cost of making patterns, castings become economical over other methods of production when quantities to be produced are adequate (Jain, 2001).

In Uganda, Obwona, Shinyekwa, Kiiza & Hisali, (2013) assert that in the 1950s, the Kilembe copper mine was the only recognised mine, whose contribution to Gross Domestic Product (GDP) was 5 per cent of the value of Uganda's exports. From the 1960s to 1988, several steel production industries were set up that include; East African Steel Corporation one of Madhivani Group Companies and Steel Rolling Mills under the Alarm Group of companies in Jinja; BM Technical Services in Mbarara and Tembo Steel Mills (Arinaitwe, 2020).

Furthermore, John Lugendo and Company Limited, one of the foundry industries founded in 1962 uses scrap to make machinery for any cottage industry such as maize processing machinery, rice machinery, sugar cane processing, crushing nuts, cutting chuff, and multipurpose mills. Bukaalamye David managing director of John Lugendo boasts of being part of the team which manufactured the Kiira EV of Makerere University (Otage, 2014). Yet in Uganda, foundry practice is still not well developed and instead, sand casting is the most commonly used method with poor quality products compared to other modern casting methods such as investment and die casting which produce superior products (Herfurth & Scharf, 2021).

2.1.1 Safety in foundry practice

Foundry practice in most cases is tagged with hazards and a poor working environment. However, according to Safe Work Australia (2013), control measures should be put in place in any foundry shop to ensure that workers are safe especially in pattern-making for the context of the study. The safety measures include; i) always operating in a well-ventilated area. Fumes and dust from combustion and other foundry chemicals, processes and metals can be toxic; ii) use nose masks and safety glasses for protection against dust from sand and high-intensity heat during the melting stage; iii) think about what you are doing at all times. iv) focus on the job at hand and the next step.

At the Kyambogo University foundry workshop, it was observed that the majority of foundry rules are followed to avoid injury or death. Foundry technicians advise students to pay attention to all notices displayed in any workshop as these safeguard users from accidents. Safety wears such as leather gloves, fireproof apron, foot and leg protection, safety glasses and caps are required against heat and molten metal. Users are warned not to participate or go near the pouring area if they have been taking medication that impairs their coordination, and judgment or have been using drugs or alcohol in the last 24 hours. However, when it comes to pattern-making stages less safety is observed yet dust and speeding machines present can cause health hazards.

2.1.2 TVET and Foundry practice

Technical and Vocational Education and Training (TVET) is a lifelong education process with attributes of general education, related sciences and technologies for acquisition of practical skills, attitudes and knowledge in different trades (Ministry of Education and Sports, 2019). Lucas et al (2012) note that vocational education aims at developing technical competence in a given trade with the following outcomes; routine expertise, craftsmanship and business mindset. In the context of this study, routine expertise is considered especially technical skills as a pre-requisite for employment due to the need to relate theory with practice.

Lucas (2014) defines routine expertise as the technical ability to execute professional activities by the manipulation of the required materials, tools and academic concepts to an acceptable standard. Technical skills indeed are the abilities for effective performance which include teamwork, presentation skills and problem-solving skills as packaged in the present teaching methods. As strengthened by the three aspects of competency in Hoffmann (1999):

(a) fundamental prerequisite and characteristics of a student, (b) evident behaviours, and (c) standard of individual routine results (Hoffmann,1999) cited in (Benazir, 2014).

Technical vocational education and training emphasizes competence acquisition for productivity (Azizi, 2015). TVET in Uganda encompasses; technical schools and institutes training (craftsman level); technical colleges training (Technician level); and Graduate engineer level training offered by universities (Ministry of Education and Sports, 2019).

Kyambogo University is an institution that was created in 2003 after the merger of then Uganda Polytechnic Kyambogo (UPK), the Institute of Teacher Education Kyambogo (ITEK), and the Uganda National Institute of Special Needs (UNISE) advance knowledge and skills at all levels; from certificate to diploma to degree and post-graduate qualifications levels (Bwana, 2018).

In most cases, foundry practice is regarded as an informal TVET yet it drives most manufacturing processes due to outdated methods of training done by master craftsmen and women leading to preparation and trades in carpentry, masonry, auto mechanics, welding and foundry (Kintu & Ahaisibwe, 2019). However, the Ugandan government has acknowledged the relevance of foundry practice by incorporating it in mechanical diploma programmes, in addition, to the diploma in electrical and certificate in fitting as a component of production technology. Most developments in TVET as pointed out in Egau and Humphery (2002) are anchored on the major recommendations in the Government White paper on Education, April

1992. TVET is geared towards enhancing youth attitudes to skilled manual work as they diverge from limited white-collar jobs (Oketch, 2014).

Despite the developments, there are challenges in TVET that are persistent and these include; inadequate basic technical skills and professional certifications for the execution of specific activities, such as in foundry; Secondly, integration of practical knowledge is partially considered in the formal training, with managers in manufacturing and production sector affirming the necessity to offer training to foundry technicians, particularly on modern technology in pattern-making (World Bank 2011 report); the Report of the Education Review Commission of 1992 cited in Olema (2018) states that;

"*No education system can be better than the quality of its teachers. Education standards are guided by qualifications and motivation of teachers".*

Olema (2018) pointed out that reputable technical and vocational training necessitates technicians with technical skills, industrial proficiency and pedagogical skills. Newly graduated craftsmen are expected work with experts who have been practising in the related field for an adequate time (Achieng, 2012). According to Obwona, Shinyekwa, Kiiza and Hisali, (2013), pattern makers cannot produce patterns for sound castings due to insufficient technical requisite skills hence lowering productivity and increasing the costs of hiring expatriates in the manufacturing sector (Obwona, Shinyekwa, Kiiza & Hisali, 2013). Hands-on training provided in technical and vocational institutions develops students' competencies needed in the manufacturing industry.

2.2 Hands-on training.

Real-life applications are provided through hands on training which is an efficient means of knowledge generation where participation in the activities is key (Donato, 2019). Also, Haury and Rillero 1994 cited in Ateş and Eryilmaz (2011) defines hands-on learning as any instructional approach where students actively participate in the manipulation objects to gain knowledge or understanding. Schmidt (2015) argues that hands-on training guides students in the transition from practising to executing the job in the workplace other types of trainings.

Hands-on training can be defined as a systematic approach to learning that requires teamwork on the side of the student and the technicians for competence acquisition. I concur with Gary's (2009) conclusion of his book hands-on training;

''If we're going to use on-the-job training anyway, let's use it well, because any carelessness in hands-on training depicts defects and fatalities,'' pg.22.

This requires mixing a little knowledge and a lot of creativity into a simple, practical system for increased productivity.

In the context of this study, the art of patternmaking is easily appreciated when students identify the types of materials used to make patterns and eventually practice with consideration of attributes that lead to sound castings such as rounded corners, smooth surfaces, pattern allowances and durability of the pattern. However, taking Gary's quotation misuse of the hands-on training approach hinders creativity because students may imitate their instructors who could also have imitated their instructors. This is because technicians may be experts at the jobs but not skilled as trainers (Gary, 2009).

2.3 Theory informing the study

The theory that informs the study is situated learning theory because it requires students to fully participate in real-life activities which aid creativity and promote safety during the community of practice.

2.3.1 Situated learning theory

Situated learning exceeds learning by doing. Lave and Wenger (1991, p. 31) assert that it requires students to participate in communities of practice where they attain mastery of theoretical concepts and practical abilities by engaging in the social-cultural environment for more understanding and contribute to social standards of their societies. Other scholars point out that situated learning theory as a learning approach insists upon contextualized, authentic instruction for effective and lifelong learning (Oliver & Herrington, 2000; Green, Eaddy, & Andersen (2018). In foundry practice, knowledge is executed from lecture rooms but more practical experience is required for students to be considered competent. Therefore, taking a project-based learning approach to teaching practical foundry practice in small groups with minimal supervision carries students to a higher level of thinking and teamwork.

Lave and Wenger (1991) argue that graduates' identities and practices are developed through engaging in participatory prospects available to them. In addition, (Wenger, 2008) points out that;

''……. knowing something entirely new, and therefore even discovering can be acts of competent participation in a practice''pg.137.

The implication of the theory to the study.

Bandura,1986 cited in Zoncita (2015) asserts that learning under situated learning focuses on observations made by students during group learning activities. This implies that students need to fully participate in foundry practice as Lave and Wenger (1991) observe that participation is the most crucial element in learning activities such as task functions and understandings. Figure 3 shows the elements of situated learning theory with participation at the centre of all activities.

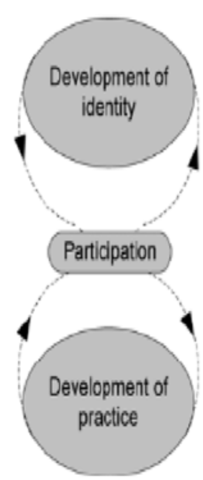


Figure 3: Situated learning Theory core components.

Source: Zoncita (2015; pg56)

Situated learning theory also emphasizes that students learn in an environment that allows them to reflect on real-world activities. This brings out the authentic contexts as illustrated in Figure 4.

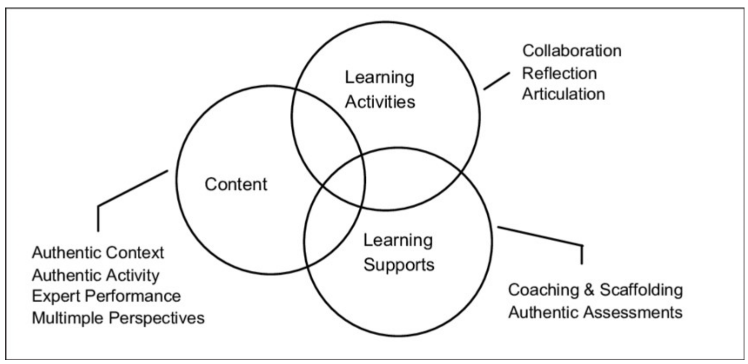


Figure 4: Showing authentic Contexts

Source: Oliver and Herrington (2000, pg7)

According to Oliver and Herrington (2000) situated learning environments reflect how the knowledge and learning outcomes are transferred to workplace settings. Emanating from a design viewpoint, the foundry shop should provide students with a variety of resources that aid the transfer of knowledge from simple to complex real-life activities. The integration of project work in course units such as foundry technology generates a reflection of the complexity of most real-life problems.

Pedagogical implications of situated learning theory and foundry practice

Situated learning emphasizes collaborative learning where students are organized in small groups. Situated learning environments have attributes such as collaboration and cooperation whereby students learn with, and from, one another. (Oliver & Herrington 2000). The pedagogical implication here is that through reflection students can deliberate on the learning process and the content given the high degrees of authenticity embedded in the tasks and contexts within which these tasks are delivered. In the foundry shop setting, students are encouraged to practice and simulate for a better understanding of the concept at hand. Moreover, students are encouraged to use reflection strategies to compare themselves with experts and with other students in varying stages of execution of activities (Oliver & Herrington, 2000).

Active group participation requires everyone's experience for the articulation of ideas. Strategies often used for this purpose include students' presentation of artefacts and the definition of students' ideas and their learning (Coghlan, 2019). The roles of the teachers are to provide different forms of learning support, particularly support in the form of scaffolding and coaching for a significant part of the period to allow learning. Foundry practice in the Department of Mechanical and Production Engineering at Kyambogo University has a programme of having different sections that handle for example; pattern making; salvaging through welding, machining; moulding; heat treatment and metallurgical inspection of final casting and all the above sections have technicians.

2.4 Gaps hindering students' competence development in foundry practice at DMPE

Bogere (2016) in his findings from the study entitled improving practical training and skills acquisition in production technology established the following gaps in the teaching of practical work; inadequate training materials, inadequate coverage of content, low emphasis on practical training and poor lecturer participation in practical training. Also, Kikoyo (2017) in his action research entitled improving teaching and learning processes in computing for mechanical engineers, established the following challenges; limited time for students to exhaust the learning content, limited computer resources, limited mentoring, dodging of lectures by technicians and students, unfavourable schedule.

2.5 Interventions to improve students' competence development

Intervention requires taking action on the strategies and activities identified by stakeholders during the planning stage of the first cycle of action research (Kikoyo et al., 2020). The researcher and participants (participating foundry technicians and students) through a future workshop laid down several strategies to enhance competence development in foundry practice which included; availing space and equipment through networking activities by technicians, group learning in manageable groups, accessibility of workshops for real-life work and increase practical time through rescheduling of practical sessions. Currently, there are several initiatives for skills development directed by the Business, Technical and Vocational Education Training (BTVET) policy and strategic plan (Ministry of Education and Sports, 2012). To meet the changing needs of manufacturing firms, teaching strategies that address large groups of students for vigorous hands-on training activities will have to change (Ministry of Education and Sports, 2019).

2.5.1 Networking activities of teachers

Networking according to Esenina, Blinov and Satdykov (2019) is presented as a way of enhancing competencies through internal or external interaction. Esenina et al, (2019) point out that internal networking is related to the conceptions of technical institutions and shared expertise. These include; participating in established networks and teams; establishing own institution through networks and teams; learning about effective team-working; work collaboratively with and support colleagues. Esenina et al, (2019) further, emphasize that a technician should not execute duty discretely but rather to cooperate with other technicians to plan, coordinate and execute the teaching and learning process together (Esenina, Blinov & Satdykov, 2019).

Anindo, Mugambi & Matula (2016) advocate for the acquisition of equipment by schools which could be rented out to small industries during holidays / non-school hours hence creating jobs for students. In line with this, Iganga technical institute acquired modern automotive machines and boosted serving the community as well as passing out graduate technicians who are competent enough (Bita, 2020).

2.5.2 Simulations and Field study

Lucas et al, (2012) assert that theory and practice are not linked when the teaching and learning processes are done in two geographical places. Computer simulation of the intended casting method before any molten metal is poured into the moulds saves costs and time. Beerly (2001) points out that sound casting can be made with the first attempt done by a skilful moulder who establishes complications in the moulding of specific design features, casting method and safety risks. However, the challenge remains with the software to use in the simulation. Also, Olema (2018) advocates for field study emphasizing that it exposes students to an industrial environment. In foundry practice, field study, simulation and information computer technology could expose students to equipment that cannot be acquired by the institution with reduced manufacturing risks.

2.5.3 Improving education and training policies

Uganda Country Report (2014) encourages the development and strengthening of technical training centres to train people in skills to practically perform technical tasks in technology-based industries that include the development of pattern-making software, ensuring product quality and performing inspection of manufactured castings.

The report further, supports the extension and technology transfer services to support product development, testing, and evaluation in the manufacturing industry. For example; the establishment of science parks and incubation services to enhance the linkage between industry, academia, and technology parks through incentives to companies that participate in technology transfer such as low-cost land, loans and extended tax holiday. Competence development in manufacturing activities increases through the implementation, development, and mastery of new technologies (Ocampo & Vos 2008). Similarly, the foundry industry provides the potential for diversification into a variety of commercial activities for economic growth.

2.5.4 Availability of equipment and tools

Foundry practice as a vocation has tools needed to complete the circle as Lind berg (2003) indicates that the importance of intellectual and physical tools of the vocation requires sets of tools, their maintenance and technical aspects such as attributes of a good pattern, for instance, pattern making hand tools such as gorges, templates, measuring tools and machine tools like mortises, flet saws, circular saws.

Nilsson (2011) in his 5T[3] Theory stress that Trust, Tutor, Tasks, Time and Tools direct hands-on training especially in the foundry where inadequacy of any of the 5Ts affects the delivery of TVET. Kemevor and Kassah (2016) point out that inadequate training materials, basic tools and

[3] Nilsson's 5T theory (Trust, Tutor, Tasks, Time and Tools).

equipment during practical training force technicians to avoid the use of demonstration methods which make students practically oriented but they rather employ the lecture methods during practical lessons. The researcher believes that the inadequacy of training materials and the large numbers of students hinder the technicians from attracting and retaining the interests of the students during practical lessons. Teaching is easier through the use of Information Computer Technology (ICT). As technicians of foundry practice, we have the challenge of changing technology, especially where computer-aided software is needed to match with the world of work.

2.5.5 Teaching and learning in small groups

Group work in foundry practical work can be defined as the collaborative interaction of students in small teams to reflect and act on knowledge construction as they complete tasks. Students develop more confidence through continuous engagement in group work and they become responsible for their own learning (Sajedi, 2014 cited in (Morris, 2016). Mintah (2014) in his conclusion, asserts that the group method, though time-consuming and demanding in terms of supervision and control, is the best way of making an impact in a large class. The proverb too many cooks spoil the broth (Tatira, 2013) implies that groups must be of a manageable size (small) for them to be executed effectively.

Mjelde and Daly (2006) point out that group work enhances a collection of technical skills and competencies needed in a specific trade. Similarly, Farrant (2002) cited Mintah (2014) in his book,'' Principles and Practice of Education'', as he pointed out the advantages of the group method of teaching that include: students actively participate in practical sessions; students work for longer hours; students can be grouped based on abilities, giving chance to the slow learners to learn at their pace without hindering the progress of the bright. Technicians can decide to use both fixed and flexible grouping in their classes since flexible group builds a community while non-flexible builds trust (Rance-Roney, 2010 cited in Morris, 2016).

2.6 Evaluate the implemented interventions to enhance students' competence development

Evaluation is a vital stage in Action Research that envisages the future projections of an organization. Evaluation is done after interventions empower stakeholders, especially technicians and students to be held accountable for the hands-on training process that leads to competence development. In reflection of this, the current study under this section answers the question; How can the department of mechanical and production engineering benefit from enhanced students' participation in foundry work?

2.7 Researcher's summary of literature review

Reflecting on the relevance of outstanding teaching and knowledge development using any vocational pedagogy, the main goal affirms that foundry practice as a vocation requires dual professionalism with both industrial skills and teaching excellence. This implies that the use of the learning theory such as situated learning in addition to field studies could increase students' participation in foundry activities with reduced safety risks consequently improving their competencies.

In this study, developing students' competencies was done through a participatory action research approach where data was collected using qualitative methods by the researcher as an active participant observer. According to Mills 2011 pg.75, participant observation is characterised by; observations of the activities, participants and physical attributes of a situation and engagement in research methodology for data collection and analysis.

CHAPTER THREE: METHODOLOGY

This chapter describes the methods that the researcher used to collect and analyse data. It describes the research design, research approach, study location, target population, sampling technique, methods of data collection, instruments of data collection, data collection procedure, data analysis, ethical considerations and reliability of data.

3.1 Action Research

Action Research is also known as participatory research, collaborative inquiry, emancipatory research, action learning, and contextual action research (Creswell, 2014). Nugent, Malik and Hollingsworth (2012) refer to Action Research as "learning by doing" whereby people in the same societal setting recognise a challenge and decide to resolve it by evaluating their efforts to satisfaction. As Coghlan (2019) points out; Action research involves a self-reflective, systematic and critical approach to action–reflection enquiry by research participants. McNiff (2002) agrees with Lewin's theory of action research that; a spiral of steps involving planning, fact-finding and execution (Lewin,1946). McNiff 2002 refers to the theory as an action-reflection cycle of developing ideas (plan), execution (act), assessment (observe), and critically think (reflect) as indicated in Figure 5.

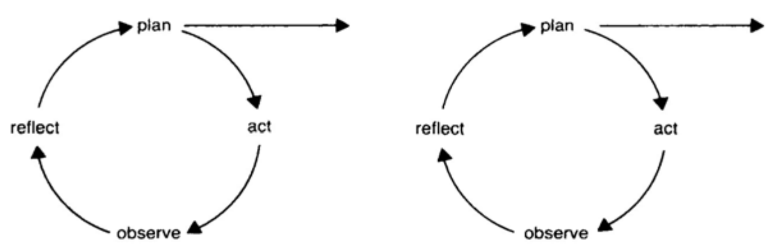


Figure 5: Sequences of action-reflection cycles

Source: McNiff (2002, pg. 54).

In the context of the study, action reflection from the researcher's point of view as a foundry technician, points out the question; what should one do to better her profession of delivering practical work for more competence development in students?

Planning: By definition of founding/metal casting, a student should be able to produce sound casting by first considering patterns. The researcher aims at producing graduates with the ability to perform metal casting processes. The researcher believes as one technician cited that there is a need to devise means of fully engaging the students in hands-on practical work. Stakeholders during a future workshop agreed upon the strategies of enhancing students' competence in foundry practice and sought for authority to conduct research.

Acting: Strategies were laid down that included internal networking among technicians in at least two more workshops. During implementation data was collected with reflections for instance; data was presented to authority for reflection after organizing and analysing and this was followed by feedback.

Observing: As students' participants, colleague technicians and the lead researcher were engaged, notes were taken in form of observations while reflecting on the research objectives.

Reflecting: Reflection through feedback was done and the set interventions were sufficient with no need to re-address the cycle by re-planning, acting, observing and reflecting, and perhaps producing a new cycle.

3.2 Research design and approach

The study employed a Participatory Action Research (PAR) design and a qualitative research approach. PAR involves the views of all stakeholders in creating knowledge upon which the researcher, together with stakeholders developed and implemented actionable strategies. The strategies aimed at improving competence development in foundry technology at DMPE. Action research is participatory in the sense that people of a particular context, design and conduct the research and reflect on its nature (Creswell, 2014). The design was suitable for this study because data was collected through shared ideas, commitment and active participation of stakeholders and the lead researcher, DMPE administrators, foundry practice technicians, lecturers and students using action research methods that are qualitative in nature including but not limited to work processes analysis, future workshop, focus group discussion, interviews, and observation. Other than written information, the researcher also used photographs as a form of evidence to triangulate data.

3.3 Location of the Study

The study was conducted at Kyambogo University in the Mechanical and Production Engineering Department (DMPE), Kampala district, Nakawa division 8 km from Kampala city and 2 km off the Kampala Jinja highway, with the main goal of improving the competencies of foundry practice students through participatory action research.

3.4 Study Population

The study involved a sample of stakeholders that engaged in enhancing students' competence development in foundry practice. These included; administrators, lecturers, students and technicians. Administrators availed information on how DMPE is managed in terms of the teaching and learning process of foundry technology; lecturers provided information on how foundry theory is related to foundry practical exercises; technicians provided information on how they conducted foundry practical exercises while students provided information on the teaching and learning process of foundry technology. In this study, lecturers and technicians were taken as teaching staff based on Kyambogo University structure. The study population and sample size are presented in Table 4.

Table 4: Study population

SN.	Stakeholders	Sample size target	Sample size actual	Sampling technique
1	Administrators	2	2	Censor
2	Lecturers	5	5	Purposive
3	Technicians	9	9	Purposive
4	TIEM3105 Students	123	23	Purposive
	Total	139	39	

Source: Primary data (2021)

3.5 Sampling method

Sample Selection; According to Creswell, (2014) purposive sampling is used in the selection of individuals because they have the experience needed in the study. Similarly, Langkos (2014) and Palinkas et al. (2015) assert that purposive sampling is a non-probability sampling technique extensively used by qualitative researchers where sample individuals are designated based on their understandings, relationships and technical knowledge about the study. Palinkas et al. (2015) further note that;

> *''Vocational knowledge and expertise; commitment and readiness to contribute; and the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner is of great importance.''*

Within this context, the number of year three students that offered foundry technology at the Department of Mechanical and Production Engineering during this study were 178 from both Bachelor in Industrial Engineering (BIEM) and Bachelor in Mechanical and Manufacturing Engineering (BEMME) programmes. BEMME students were selected because their programme requires them to be fully involved in the manufacturing processes (Kyambogo University, 2015). According to Mugenda and Mugenda (2003), a sample size of 10% - 50% of the target population is acceptable in descriptive research. A sample of 23 students was used based on voluntary participation in the study and also based on the definition of foundry practice which requires full participation at all the stages of production up to the final product. However, the stage of pattern-making is more important because it dictates the final product. After studying the literature on different sampling methods, the researcher used purposive sampling as the best choice. On the other hand, all the technicians, lecturers and administrators were selected by the census. The census technique is where all the participants are involved in the study mostly in small groups (Bogere, 2016).

3.6 Data collection method and tools

Work process analysis was carried out during the initial stages of the study to investigate the teaching and learning process at DMPE in the foundry technology course unit. This involved the use of focus group discussions and documentary analysis. The findings of the analysis provided a basis for the statement of the problem, the objectives and the research questions. Other data collection methods included; interviews, future workshops, observations and audio-visual materials.

3.6.1 Focus Group Discussions (FGDs)

Focus Group Discussions, (FDGs) involve dialogue between the researcher and a group of participants of different categories of stakeholders (Kikoyo, 2017: pg. 27). The researcher conducted focus group discussions with students, administrators, lecturers and technicians at the initial stage of the study. They were probed to respond to the questions using the focus group guide, Appendix XII. Focus group discussions reveal a wealth of detailed information and deep perception when well executed to a small group of participants (Nabaggala (2015); Nichelle & Nagle, 2013). In this study, the unstructured interview method was used in focus group discussion to determine gaps hindering students' competence development at DMPE. Personal and unstructured interviews aim at identifying participants' feelings about a particular area of the study (Turner, 2010).

3.6.2 Document analysis

Creswell (2014) defines documentary analysis as written information or physical objects analysed for study purposes to gather data such as; machine tool manuals, textbooks, journals, registers, newspaper articles, letters and minutes taken on the subject under study. A thorough document review of the latest TVET- related documents, such as TVET policy, as well as revised Kyambogo University 2015 BEMME year three semester one curriculum was extensively conducted to identify the learning outcomes of foundry practice students.

In addition, artefacts such as students' workpieces and machines were analysed. The document review also informed the development of focus group discussion guides and evaluation tools, all of which contributed to generating problem statement, objectives and strategies to enhance the competencies of students in foundry practice. The researcher also read soft copies from search engines that informed the literature review and methodology. Creswell (2014) points out that documents provide data that is ready for analysis without transcription which is required in other methods such as observation. However, the method of study was time-consuming, required research method skills for reflection and was costly and on the other hand, created bias on some documents that needed subscription.

3.6.3 Interviews

In this study, in-depth interviews were used through probing for responses during the discussion. In-depth interviews are personal and unstructured interviews, whose aim is to identify participants' emotions, feelings, and opinions regarding a particular research subject (Langkos, 2014). To investigate the gaps in competence development and to evaluate the implemented interventions, the researcher considered the participants' experiences during the practical sessions, as well as their opinions, feelings, knowledge, and physical understandings that made the interviews more meaningful. The way that the participants planned and moulded the patterns allowed the construction of knowledge in the entire production process and improved the ability to perform tasks.

3.6.4 Future Workshop

The future workshop was conducted after the work process analysis. According to Jungk and Müller (1987 cited in Vidal, 2006), a Future Workshop (FW) entails five stages/phases:

> ***The preparation phase****: the lead researcher organises the local facilities for the workshop, invites participants, and sets the rules and the timetable.*
>
> ***The critique phase:*** *by using the creative technique (brainstorming) of structuring and coding ideas into main sub-themes, the problem is critically and thoroughly discussed and investigated.*
>
> ***The fantasy phase:*** *Using the brainstorming technique, the participants work out a utopia phase where an exaggerated picture of the future is drawn.*
>
> ***The implementation phase:*** *the ideas found are checked and evaluated in what concerns their practicability. An action plan is elaborated.*
>
> ***The follow-up phase:*** *the action plan is monitored while noticing the changes are performed and if needed new FWs are planned.* **Details are indicated in Section 1.2.3.**

3.6.5 Observations

Hughey (2020) defines observation as a systematic method of selecting, watching, listening, reading, touching and recording behaviour and attributes of living beings and objects. During the study, the researcher used an observation checklist Appendix XII to observe the participants as they implemented the different interventions.

The researcher also asked open-ended questions while students freely provided their views. In addition, the researcher being part of the group recorded events as they transpired. However, Creswell (2014) argues that the researcher's participation comes with limited data since it is difficult to take notes while participating. The researcher took notes at the end of each session and related them with data from observations recorded by students in their notebooks which was later analysed, hand-coded and presented.

3.6.6 Audiovisual materials

During the study, materials such as photos and pattern workpieces were secured as Creswell (2014) points out that audio-visual provides an opportunity for participants to share their authenticity as it captures the attention visually. The researcher used a camera to capture photos which aided the triangulation process. However, taking photos kept on disrupting the responses but the researcher sought permission from the participants. On the other hand, photos require interpretation due to the rich information from them (Creswell, 2014). Therefore, the researcher selected photos that were directly related to the methods of data collection used in the study.

3.7 Data collection tools

3.7.1 Open-ended questionnaires

The purpose of the questionnaire was to triangulate the data obtained from the focus group discussions and the follow-up stage of evaluation. According to Kumar (2011), an open-ended questionnaire is an instrument for data collection that avails participants with the chance to express themselves freely. The tool was designed with both close-ended and open-ended questions to explore the reasons for the closed-ended responses **Appendix XII.** A Likert scale designed with five levels of responses was used to determine the rating of the four interventions**.** For this study, participants revealed that the four interventions were relevant in developing students' competencies. A Likert scale (psychometric response scale) provides participants partialities or degrees of agreement with a set of statements (Bertram, 2013).

3.7.2 Assessment tool

The competence-based assessment was done throughout the implementation stage to evaluate students' competencies in foundry practice. The assessment tool used during students' presentations of final products was designed for the entire pattern-making (Appendix XII). The methods and tools used in the study are summarized in Table 5.

Table 5: Summary of methods and tools used in the study

Sn	Methods	Tools
1	Focus Group Discussions (FGD)	Focus group discussion guide, Evaluation tool (open-ended questionnaire), Assessment tool.
2	Document analysis	Programme book Kyambogo University BEMME (2015), TVET Policy (2019), Machine tool manual, Online journals.
3	Future workshop	Focus group discussion guide
4.	Observations	Observation checklist, camera, participants' notebooks
5.	Audio-visual materials	Camera, pattern workpieces,

Source: Primary data (2021)

3.8 Research process

Before going out for data collection, the researcher obtained a letter from the faculty of vocational studies at Kyambogo University addressed to the Department of Mechanical and Production Engineering for the study. This letter introduced the researcher and explained the purpose of the study. The researcher then took into consideration the nature of the population and then designed a focus group guide, and an observation guide to cover the objectives of the study. These were the main research tools. The researcher then went out to the field and interviewed the foundry students during their practical engagements as they kept taking notes in their notebooks. The observation method during the FGDs was used to confirm the responses. Photographs were taken to strengthen the validity of data while Administrators were interviewed individually in their respective places of work upon their request. Students presented artefacts and were assessed based on pattern attributes and lastly an evaluation meeting was organized to assess the impact of the study.

3.9 Data analysis

Semi-structured interviews of the foundry technology students and technicians were carried out. Informants' experiences, thoughts and feelings about the hands-on training activities were recorded in notebooks. The lead researcher regularly reviewed interview transcripts. Data was analysed in terms of students' productivity (participation) to enhance competence development in foundry practice. The qualitative approach allowed for an in-depth aspect of educational issues and also allowed the researcher to gain an understanding of the participants' relation to their context to foundry practice in particular. In analysing selected intended documents, the focus was on content knowledge that informed the study.

Findings were presented in a form of responses to the four research questions:

What gaps are hindering students' competence development in foundry practice at the DMPE?

What interventions can be taken by students and staff to address the gaps in students' competence development in foundry practice at DMPE? How can the identified interventions be implemented to enhance students' competence development in foundry practice? What are the results of the implemented interventions aimed at enhancing students' competence development in foundry practice?

3.10 Ethical consideration

The research design, interpretation and practical developments were all generated by all stakeholders relevant to the study which makes the research ethical (Connelly, 2014). All participants were informed about the objectives of the study while being reassured that all answers were treated with confidentiality. The researcher further discussed the research ethical issues and principles used in guiding the study with the head of the department and gained his approval. The researcher also explained each feature of the research extensively to the research supervisor who kept guiding the study throughout the future workshop, recording data, developing data collection tools, data analysis and presentation. In addition, photography was carried out with permission from the participants.

3.11 Validity of data

The researcher used several steps to ensure sincerity of the collected data. Presentations of pattern drafts and the patterns made and assessed using a competence-based assessment tool with at least three pattern attributes were better than verbal reporting of the activities due to the articulation of ideas that were involved. Similarly, McNiff, (2002) asserts that students' presentations of artefacts bring out the full explanatory space of the reality of people's practice more adequately than verbal reports.

Triangulation, as emphasized by Creswell (2014) requires the use of different data collection methods to obtain information from participants, sources and at different stages of the study. Observations and focus group discussions were used and confidence in findings in the cyclic process flow was increased while further triangulation of data was done to guard against researcher bias (Burns, 2015).

3.12: Reliability of Instruments

Creswell (2014) defines reliability as the measure of consistency. The researcher consulted and worked hand in hand with supervisors to develop items on the instruments which were used to collect accurate and desired data. The researcher pre-tested the focus group discussion guide and evaluation tool with the same participants at two different times at an interval of one month to see whether the key questions could easily be understood to avoid ambiguity and misinterpretation. Participants' responses were related that gave green light to the use of the designed data collection tools.

CHAPTER FOUR: ACTION IMPLEMENTATION, RESULTS AND EVALUATION

This chapter presents the results of the study generated from the future workshop, observations, interviews, focus group discussions and documentary analysis that were employed to explore strategies for enhancing students' competence development in foundry practice at the DMPE. The key participants in the study were Bachelor's degree students that offer foundry technology, teaching staff (technicians and lecturers) who handle foundry technology practical work and two administrators (examination coordinator and the head of the department of mechanical and production engineering). These provided responses and descriptions that the researcher based on to organize and systematically present data.in the order of set objectives in addition to observations made during the study.

Evaluation of implemented interventions was conducted through focus group discussions and the use of both evaluation and assessment tools. The assessment tool was used as students presented their pattern workpieces which was the practical exercise set to evaluate their competence in foundry practice.

4.1 Hindrances to students' competence development in foundry practice at DMPE

From the work process analysis, the researcher found out the gaps hindering competence development in foundry practice are; inappropriate method of assessment, failure to cope with the changing technology (equipment at the DMPE being different from those in the industry), the poor work attitude of students towards practical work, more emphasis on theory than practical work at the DMPE, the large number of students enrolled per programme; limited time allocated for practical work on the timetable; inadequate training facilities and equipment; delayed delivery of training materials for a given semester and fear of safety-related foundry hazards.

The researcher observed that students did at most two practical exercises out of seven topics in the course outline of foundry technology as shown in the 2015 revised curriculum. In the interaction with technicians, one technician said that:

> ‘‘They *are forced to teach theory due to the large number of students and the inadequate practical materials in addition to the few equipment making the practical time consuming hence low content coverage*’’.

During the future workshop, the stakeholders agreed on four interventions that increased students’ participation in competence development (Section 1.1.2).

4.2. Interventions that enhance students' competence development.

The researcher used focus group discussions and observations to gather relevant data while identifying interventions that enhance competence development in DMPE at Kyambogo University. The interventions that were agreed upon by stakeholders in the future workshop to enhance students’ competencies in foundry practice included**;** rescheduling practical sessions, networking with technicians, equipment and space availability, use of group learning and advocating for accessibility to DMPE foundry workshops (Section 1.1.2).

4.2.1 Rescheduling practical sessions

During the focus group discussion, students suggested rescheduling the foundry technology practical sessions to lessons after break time. Students said that after break time there were two extra hours which were adequate for their practical work without encroaching on the next lecture. One student participant pointed out that before this study, they had to stop their foundry practical session before the end of the two practical hours to restore the work area and prepare for the next lecture. One technician participant agreed as he mentioned that due to limited time, they focused on reduced content coverage to at most two practical exercises for the entire course unit. The researcher observed delayed feedback with students being assessed on the final product rather than the process.

4.2.2. Space and Equipment availability.

The researcher observed that there was a need of availing more space and equipment for carrying out practical work in foundry practice at DMPE in Kyambogo University. During this study, the researcher observed that foundry practical exercises were organized by technicians before the practical session through interpretation of drawings, preparation of equipment and raw materials. However, these were not sufficient. Additionally, there was poor housekeeping observed whereby, moulding boxes and silica sand spread in all corners which limited free movement during practical work, hence creating an unsafe environment for both the students and the technicians. In addition, the researcher observed that students were overcrowded around technicians due to limited working space.

During the focus group discussions, a student revealed that some processes were not carried out due to unsolved breakdowns, particularly of an air blower that was used hand in hand with the forge furnace. Students commented during the focus group discussion that the tools and equipment were inadequate. During focus group discussions, a student participant commented:

> ‘‘*We are mechanical students in case a machine breaks we should be given chance to repair*’’.

Another student lamented that it was shaming for the department to hire someone to carry out minor repairs when they are mechanical students.

Furthermore, the researcher observed that it would be good to network with technicians from the Department of Civil and Building Engineering (DCBE). This would aid in accommodating the large numbers of students and completing the foundry practice processes. The Head of Department (HoD) from DMPE consented to the idea of networking with technicians and introduced the researcher to the Department of Civil and Building Engineering (DCBE) to implement an action research strategy of availing space and equipment.

4.2.3 Use of group learning for more hands-on activities

The researcher observed that group learning was a good intervention that enhanced competence development in foundry practice. This was because group learning is an active hands-on training that extends to social lifelong learning. Kikoyo (2017) pointed out that group learning occurs in social contexts through interactions with others (Kikoyo, 2017 pg. 31). The researcher noted that group learning leads to communication (discussion, collaboration and feedback) which maximizes students' ability to construct knowledge.

4.2.4 Advocate for accessibility to DMPE workshops

Students and technicians jointly advocated for accessibility to DMPE workshops to carry out real-life activities in foundry practice brought by the community. The HoD being a stakeholder granted permission. During focus group discussions, the students said that accessibility would aid them to build confidence in real-life activities and help them reduce defects. However, the technicians mentioned that it takes time to build confidence in a student and this comes with rejects and time wastage due to reworks, on the other hand, the students gain full supervision with immediate feedback.

4.3 Implementation of the identified interventions to enhance competence development in foundry practice at DMPE

The researcher collected data from the implementation of the identified interventions to enhance competence development which was generated through brainstorming in the future workshop. The stakeholders agreed to implement the strategies and an action plan was drawn. The interventions to be implemented included; an increase in practical time by the rescheduling of the practical sessions to lessons after break time on the timetable; use of group learning in groups of five maximum students to minimize redundance and maximize interaction and networking with technicians from DCBE workshops for space and equipment availability. The researcher used a focus group discussion guide and observation checklist to gather relevant data. The plan for implementation of interventions is shown in **Table 6.**

Table 6: Implementation of the interventions to enhance competence development.

S No.	Interventions	Implementation
1	Reschedule practical sessions to lessons after break time to increase the practical time.	The administrators changed foundry technology practical sessions to lessons after break time and in special cases, the lesson that followed was shifted.
2	Space and equipment availability through networking with technicians from DCBE and DMPE. DMPE foundry shop was organised. In addition to the preparation of a maintenance plan.	The head of the department of mechanical and production engineering introduced the lead researcher to technicians in DCBE workshops for space and equipment A maintenance plan for the forge furnace and computer numerically controlled milling machine was developed by students and the lead researcher.
3	Use of group learning for more students' participation in hands-on activities	Students were divided into small groups of five. These worked from the technological workshop, DCBE carpentry workshop and workshops at DMPE in Kyambogo University.
4	Advocate for accessibility of DMPE workshops to real-life activities brought by the communities	The HoD allowed the utilization of workshops by technicians and students on community work during the study.

Source: Primary data (2021).

4.3.1 Procedure for implementation

4.3.1.1 Rescheduling of practical sessions for more practical time

The Head of the department of mechanical and production engineering together with the examination coordinator rescheduled the foundry technology practical sessions to lessons after break time on the year III BEMME timetable. Considering that at that time, there was a two-hour lunch break before the next lecture. The increase in practical time was achieved by the rescheduling of practical sessions to lessons after break time before lunchtime on the revised timetable as shown in **Figure 6.**

KYAMBOGO UNIVERSITY

Final Copy

Department of Mechanical & Production Engineering

Bachelor of Engineering in Mechanical & Manufacturing Engineering

BEMME Year III — Academic Year 2020/2021, Semester I

Day	8:30 – 9:30 am	9:30 – 10:30 am	10:30 – 11:30 am	11:30 12:30	12:30 – 2:00 pm	2:00 – 3:00 pm	3:00 – 4:00pm	4:00 – 5:00 pm	5:00 – 6:00 pm	6:00- 7:00 pm	7:00 – 8:00 pm	8:00 – 9:00 pm
		EVENING PROGRAMME										
Monday	TMME 3101				L	TMME 3102		TMME 3101		TMME 3102		
Tuesday	TMME 3103			TMME 3101	U	TMME 3102		TMME 3101	TMME 3103			
Wednesday	TMME 3105			TMME 3103		TMME 3105		TMME 3103	TMME 3102			
Thursday		TMME 3104			N	TIEM 3105		TMME 3104		TIEM 3105		
Friday	TMME 3105		TIEM 3105-P		C	TMME 3104		TMME 3105		TMME 3105		
Saturday			TIEM 3105-P		H	TMME 3104						

Course Code /Title	Student Numbers	Lecturer	Technician(s)
TMME 3101: Analysis of Structural Designs (3CU)	129	Mr. Ssevume Patrick/	
TMME 3102: Analysis of Machine Mechanisms (3CU)	129	Mr. Kiiza Ronald	
TMME 3103: Applied Thermodynamics (3CU)	129	Mr. Kiiza Ronald	Mr. Ongora Solomon
TMME 3104: Fluids Mechanics Advanced (3CU)	129	Mr. Okumu Patrick	
TMME 3105: Research Methods (3CU)	129	Dr. Wandera Catherine/	
TIEM 3105: Foundry Technology (4CU)	129	Ms. Namutebi Dinah	Mr. Oryang David/ Ms. Namutebi Dinah

Figure 6: Rescheduled practical sessions on BEMME year III semester I timetable. Source: Field data (2021).

The reviewed timetable in Figure 6; shows the increase in practical time for foundry practical sessions. The increase in practical time is given in **Table 7**.

Table 7: Increase in practical time per week from the rescheduling of the practical session.

Practical Area	Practical hours per week						
	Practical time as per curriculum	**Before rescheduling**			**After rescheduling**		
TIEM 3105		Preparation	Actual practical. time	End of practical	Preparation	Actual practical time	End of practical
Day	2 hours	11 minutes	1hour 39 minutes	10 minutes less	11 minutes	2 hours	15 minutes more
Evening	2 hours	13 minutes	1hour 37 minutes	10 minutes less	15 minutes	2 hours	17 minutes more
Average practical time	2 hours	12 minutes	1hour 38 minutes	10 minutes less	13 minutes	2 hours	16 minutes more

Source: Primary data

The results in Table 7 show that the practical time increased from 2 hours to 2 1/2 hours per week. Technicians were able to complete planned activities in demonstration of complex moulding and melting processes in a practical session by extending the practical time by 20 minutes.

Before this study, the researcher observed that practical sessions started 12 minutes after the slated time due to the preparation of training material and equipment by technicians. Additionally, students took time to present themselves for practical sessions. The practical sessions ended 10 minutes before the allocated time causing a loss of 22 minutes. The HoD mechanical and production engineering worked hand in hand with the examinations coordinator to reschedule the practical sessions to time after break time to allow an extension within lunchtime. The researcher observed a total change in time of 29 minutes additional time.

A student respondent during the focus group discussions said that:

> ‘‘*We managed to complete the pattern-making with constant feedback from the technicians by exploring the different materials while putting into consideration the attributes of a good pattern*’’.

Another student respondent said:

> ‘‘*this time allowed for preparation stage, a better understanding of the stage and its effect on the final product.*’’

A student respondent pointed out that;

> ‘‘*pattern making was one of the processes that needed extra time however when the extra time exceeded 30 minutes, students began to lose concentration by continuously moving out of the workshop.*’’

During the study, the researcher observed that students were actively engaged in their practical exercises hence concentrating for utmost 30 minutes after the scheduled 2 hours.

In the focus group, discussion technicians pointed out that:

> *‘‘Before this intervention, they were disappointed with students who ended practical sessions before time to prepare for the next lecture. This dragged the practical sessions yet the class was big with limited practice time in a semester*.’’

However, with the rescheduling of practical time close to lunch break, students completed their practical work as planned hence a wider content coverage (complex moulding, pattern making, core making, melting and inspection of casting).

4.3.2. Space and Equipment availability.

The problem of limited space and equipment was addressed through the following measures;

The organisation of the foundry workshop; the foundry shop was organized by carrying out housekeeping of equipment and training materials as shown in Figures 7 and Figure 8. Before the study, moulding boxes and silica sand were spread in all corners of the workshop which limited movement making the foundry layout a foundry safety hazard to the technicians and the large numbers of students. The researcher observed students working under scorching sunshine in a bid to create space for practical work.

One technician mentioned that;

> ‘‘*The students are many which limits the availability of space and equipment and forces them to limit the number of practical exercises given to students’’.*

Housekeeping created space for free movement in the workshop which reduced foundry safety hazards such as slipping especially during the melting stage.

Preparation of maintenance plan; the researcher and the participating students developed a maintenance plan for the CNC milling machine and forge furnace. This was done using manuals for the identified machines, the expertise of technicians from DCBE with similar machines for the required maintenance activities and the necessary resources. The researcher observed that the identified machines did not have history cards.

The researcher further observed that the blower used on the forge for melting metal was of low capacity and could not run for more than 4 hours without replacing carbon brushes.

One technician respondent in the focus group discussions revealed *that;*

> *‘‘before the study, whenever the blower failed, the students had to forego practical exercises in making metallic casted patterns.*’’

After generating a history card and maintenance plan (see Appendix X and Appendix XI) for the forge that aided proper and timely maintenance of equipment, the researcher observed increased students’ participation in pattern making of metallic patterns.


Figure 7: Before organizing the workshop. Figure 8: After organizing the workshop.

Source: Primary data.

The HoD mechanical and production engineering introduced the researcher (Appendix VI) and the participants to the Department of Civil and Building Engineering (DCBE) in a bid to implement the action strategy of availing space and equipment. Based on the capacity of the workshops, students were distributed as follows; One group was taken to carpentry workshop DCBE, three remained in production workshop DMPE while one group did practical work from technological workshop, DCBE. See (Appendix VII) for those that carried out pattern-making practical work from the technological workshop.

Networking with technicians from the Department of Civil and Building Engineering (DCBE) aimed at accommodating the large numbers of students and completing the foundry practice process because they possess similar machines. From focus group discussions, one of the technicians said that;

> ‘‘*Space and equipment were availed that simplified work and allowed tapping of knowledge from technicians from DCBE.’’*

However, one technician respondent pointed out *that;*

> *‘‘The workshops are also small and have students from DCBE timetabled for the same facility*.’’

The researcher observed that this was an administrative challenge that was to be addressed by the generation of a clear timetable and motivating the technicians involved with the extra load. On the other hand, the students were able to accomplish their tasks using the technicians and machines from DCBE.as shown in Figure 9.

Figure 9: Students participating in the pattern-making process with Technician at Carpentry shop DCBE.

Source: Primary data

4.3.3. Use of Group learning with more hands-on activities

Group learning is an active hands-on training that extends to lifelong learning within the social context (Kikoyo, 2017 pg. 31). Groups were formed to increase students' involvement in the hands-on training in pattern making which they later presented in form of display and assessed following a set assessment tool. Students organized themselves in groups of five with members they liked to work with because of trust and confidence. The groups were guided by technicians that set the practical work, guiding principles such as active participation for all members and selected team leaders.

During the focus group discussion, one technician pointed out that;

> ''*grouping students in groups of five or seven allows further grouping that develops leadership skills among students and a sense of accountability that calls for fidelity by each group member.''*.

On the other hand, one student participant narrated that;

> ''*group learning created space in the workshop, access to machinery, aided teamwork and communication reducing on the passiveness of large groups.''*

However, one technician revealed that;

> ''*Group learning required a lot of involvement by the technician and was time-consuming*.'' Figures 10 and 11 show students working in groups.

Figure 10: Students melting metal at DMPE workshop. Figure 11: Students working in groups on core making

Source: primary data

4.3.4. Accessibility of DMPE workshops to real-life activities brought by the communities

In this study, accessibility to DMPE workshops to carry out real-life activities brought by the communities exposed students to challenges in real-life practical work as shown in Figure 12.

Figure 12: Technician-guided students as they worked on the client's work.

Source: Field data (2021)

The researcher observed that real-life activities-built students' confidence. The HoD mechanical granted the researcher and study participants permission to receive work from the community which was done outside the timetabled practical sessions.

Technicians received work from clients and worked hand in hand with students to generate the sequence of operations. The technicians demonstrated and fully supervised clients' work such as; making a metallic pattern for a simsim tray and production of brass insignia castings. Furthermore, a visual inspection of the pattern was made for quality control of the final product based on generated assessment tool (Appendix XII) and reworked on the workpieces with minor defects as shown in Figure 13.

Figure 13: Students, a technician and the researcher during a rework on insignia (client's work).

Source: field data (2021)

During a focus group discussion, a student demanded a display of work by the technicians to motivate students' performance.

One Technician said;

> ''*They felt that real-life foundry activities brought by the clients exposed students to a variety of challenges in the engineering sector and gave ample time to students to practice''.*

Another technician said that;

> ''*Some clients are not comfortable with students learning on their work due to the wastage of material and time.''*

However, the researcher observed active participation in real-life activities with close supervision of students, which reduced the reworks as students continued to develop their confidence and further increased productivity.

4.4 Evaluation of the implemented strategies

Follow-up of the implemented strategies was done using an evaluation tool while the process of pattern-making was evaluated using an assessment tool designed with three attributes to determine a sound pattern during the presentation exercise of finished patterns (Figure 15). The evaluation was done on how well the technician performed the task while an assessment was done to check whether learning took place.

4.4.1 Results from Evaluation tool.

From the evaluation tool of the implemented strategies,

The evaluation of implemented strategies involved analysis and reflection of completed activities during the implementation process. The evaluation involved the participation of stakeholders who willingly participated in the implementation process of the following strategies;

i. Rescheduling practical sessions after break time to increase the practical time.

ii. Space and equipment availability through networking with technicians from DCBE and DMPE and preparation of maintenance plan.

iii. Use of group learning with more hands-on activities.

iv. Advocating for accessibility of DMPE workshops to real-life activities brought by the communities.

The assessment of the implemented strategies was subsequently presented following evaluation meetings with stakeholders as shown in Figure: 14.

Figure 14: Evaluation meeting carried out on 18th March 2021

Evaluation of rescheduling of practical sessions; Evaluation was done using an evaluation tool (**Appendix XII)** where students, lecturers and technicians' views were noted in questionnaires. The average weighted rating (AWR) was obtained using the Likert scale. On the Likert scale; Agree to a large extent would score 5; Somewhat agree score 4; Neutral score 3; Somewhat disagree score 2; Do not agree at all score 1. The weighting was the number of respondents. The average weighted rating (AWR) for Students and Technicians were calculated as shown below;

$$\text{Students AWR} = \frac{(5x18) + (4x1) + (3x1) + (2x0) + (1x3)}{23} = 4.35$$

$$\text{Technicians AWR} = \underline{(5x11) + (4x0) + (3x0) + (2x0) + (1x1)} = 4.67$$

12

The results from the questionnaire on the evaluation of rescheduling practical sessions are given in **Table 8.**

Table 8: Results from the evaluation tool on benefits of rescheduling practical time

Respondents	Agree to large extent	Somewhat agree	Neutral	Somewhat disagree	Do not agree at all	Number of respondents	Average weighted rating
Technicians / Lecturers	11	0	0	0	1	12	4.67
Students	18	1	1	0	3	23	4.35

Source: Primary data.

The results in Table 8 show that students agreed with a rating of 4.35 out of 5 that rescheduling practical sessions benefited their competence development. Both technicians and lecturers agreed with a rating of 4.67 out of 5 that rescheduling practical sessions benefited students' competence development.

Increased practical time was achieved by rescheduling practical sessions after break time (Table 7). Students that agreed said that;

> ''*They were able to participate in the preparation of practical work, completion of pattern making assignments and analysed the defects due to pattern-making process on the final casting using visual inspection*.''

On the other hand, technicians that agreed said that they were able to give immediate feedback to students by assessing the process and not the final product (Appendix XII).

However, during the evaluation meeting, participants pointed out that;

‘‘*There was a challenge of exhaustion on the side of both technicians and students that limited their concentration towards work and inadequate foundry practical materials to complete the entire foundry process during the extended time.*’’

Inadequate training materials were overcome by the use of materials brought by the community and recycling of components from previous foundry practical exercises.

Evaluation of Space and Equipment availability; The evaluation results using the Likert rating scale on creating space and equipment availability are given in **Table 9**. The average rating was obtained as shown below;

$$\text{Technicians} = \frac{(10x5) + (0x4) + (0x3) + (2x2) + (0x1)}{12} = 4.5$$

$$\text{Students} = \frac{(19x5) + (0x4) + (1x3) + (0x2) + (3x1)}{23} = 4.39$$

Table 9: Results from the evaluation tool on benefits of space and equipment availability

Respondents	Agree to large extent	Somewhat agree	Neutral	Somewhat disagree	Do not agree at all	Number of respondents	Average weighted rating
Technicians / Lecturers	10	0	0	2	0	12	4.50
Students	19	0	1	0	3	23	4.39

Source: Primary data

The results in Table 9 show that technicians and lecturers agreed with a rating of 4.50 out of 5.0 that, students benefited from the arrangement that made space and equipment available. Students agreed with a rating of 4.39 out of 5.0 that they benefited from the arrangement that made space and equipment available. This was done by organizing the workshop and use of related equipment in other workshops such as those at DCBE.

Students benefited from space and equipment and presented artefacts from the melting stage and finishing stage (Appendix XIII). Those that did not agree said that;

> ‘‘*This intervention could be handled best by the administration who needed to streamline the logistics that are involved but doing it on friendly grounds is not sustainable, especially networking with other technicians for the increase in space and equipment to large numbers of students*’’.

The HoD advised the participants to utilise the facilities and manpower at DMPE while advocating for more manpower and foundry equipment.

On the other hand, the technicians that agreed said that;

> ‘‘*networking allowed students to handle especially the melting of metal instead of lamenting over the forge blower that needed repair*’’.

Use of Group learning for more hands-on activities; Groups of five students were created. Evaluation results from the evaluation tool on group learning are given in Table **10**. The average weighted Likert rating (AWR) was as follows;

$$\text{Technicians} = \frac{(5x12) + (4x0) + (3x0) + (2x0) + (1x0)}{12} = 5.00$$

$$\text{Students} = \frac{(5x\ 21) + (4x1) + (\ 3x0) + (\ 2x0) + (1x1)}{23} = 4.78$$

Table 10: Results from the Evaluation tool on benefits from the use of group learning for more hands-on activities.

Respondents	Agree to large extent	Somewhat agree	Neutral	Somewhat disagree	Do not agree at all	Number of respondents	Average weighted rating
Technicians / Lecturers	12	0	0	0	0	12	5.00
Students	21	1	0	0	1	23	4.78

Source: Primary data

The results in Table 10 show that all technicians and lecturers agreed with a rating of 5.0 out of 5.0 that, students benefited from group learning. The students agreed with a rating of 4.78 out of 5.0 that they benefited from group learning. The technicians and lecturers said that;

> ‘‘*group learning motivates them to closely supervise manageable numbers of students and allows immediate feedback and mentoring*.’’

One technician said;

> ‘‘*with group learning, they were able to assess the process instead of the final product and also social interaction with students yielded new ideas in the field of foundry practice.’’*

Though students got a chance to practice, both technicians and students were challenged with the ratio of students to equipment that kept dragging some groups back. This could have contributed to those that somewhat agreed and the ones that did not agree at all.

Advocating for Accessibility of DMPE workshops to carry out real-life activities brought by the communities; The evaluation results using the Likert rating scale on the accessibility of DMPE workshops to carry out real-life activities brought by the communities are given in **Table 11**. The average rating was obtained as shown below;

$$\text{Technicians} = \frac{(12x5) + (0x4) + (0x3) + (0x2) + (0x1)}{12} = 5.00$$

$$\text{Students} = \frac{(15x5) + (3x4) + (1x3) + (0x2) + (4x1)}{23} = 4.09$$

Table 11: Results from the evaluation on benefits from Advocating for Accessibility of DMPE workshops to real-life activities brought by the communities

Respondents	Agree to large extent	Somewhat agree	Neutral	Somewhat disagree	Do not agree at all	Number of respondents	Average weighted rating
Technicians / Lecturers	12	0	0	0	0	12	5.00
Students	15	3	1	0	4	23	4.09

Source: Primary data (2021).

The results in Table 11 show that all the technicians and lecturers agreed with the rating of 5.0 out of 5.0 that accessibility to DMPE workshops to real-life activities brought by the communities benefited students. Students agreed with a rating of 4.09 that accessibility to DMPE workshops to carry out community activities benefited them. Three out of 23 somewhat agreed while only 1 student was neutral and (4 out of 23) students did not agree at all with the accessibility of DMPE workshops by the communities with real-life activities. Community activities gave chance to students to be exposed to a variety of processes for example use of molasses sand to cast brass insignia and the design of simsim die casting. This increased students' confidence due to the continuous practice in sand preparation and design of patterns. Those that disagreed could probably be due to the fact stated by one technician in an interview that;

> ''*as students learn they tend to waste clients' materials due to the number of rejects made before mastering and the fear of poor-quality work which results into reworks.*''

Indicative weighted average ratings were calculated for the implemented strategies for enhancing competence development using the Likert scale. The summary of the rating of the implemented strategies is shown in Table 12.

Table 12: Summary of analytic ratings of the implemented strategies.

		Respondents		
S No.	Strategies	Students	Technicians	Overall rating
1.	Rescheduling practical sessions close to break time to increase the practical time	4.35	4.67	4.51
2.	Space and equipment availability	4.39	4.5	4.45
3.	Use of Group learning for more hands-on activities.	4.78	5.00	4.89
4.	Accessibility of DMPE workshops to real-life activities brought by the communities	4.09	5.00	4.55

Source: Primary data

The results from the summary of the analytic rating table show that; the use of group learning for more hands-on activities was rated highest at 4.78 and 5.00 by students and technicians respectively. This was followed by a space and equipment availability rating of 4.39 by students while technicians preferred the accessibility of DMPE workshops to real-life activities brought by the communities as being more relevant in hands-on training with a rating of 5.00. Overall rating of group learning as the strategy had the highest rating followed by the accessibility of DMPE workshops to real-life activities brought by the communities. Space and equipment availability ranked lowest. This could mean that despite the uneven results if space and equipment were available the other factors are important such as group learning.

In the evaluation focus group discussion, the students indicated the following on space and equipment availability;

A student as quoted;

> *''I have been able to tap knowledge and experience from other technicians from other departments and sections who took us through the computer numerical control Appendix VIII.''*

Another student respondent mentioned that they benefited from this intervention as he said

> ''*the scorching sun had become part of us during foundry practical.*''

A student respondent out rightly said;

> *''working with other technicians gave us chance to tap the knowledge and reduced the challenge of inadequate technicians to handle practical work.*''

On the other hand, another technician admitted that;

> ''through *networking our skills as technicians are enhanced''*.

This is in line with Esenina et al (2019) in their expression that the role of the VET teacher has evolved to cooperate with other teachers to plan, coordinate and carry out teaching together.

The researcher observed that engaging students from different workshops, increased the number of patterns made and with close supervision, the quality of work done was monitored. In addition, several foundry processes were completed. However, during a focus group discussion, a technician pointed out that;

> ‘‘*networking could work best with administration involvement for logistics and avoid collusion in the workshop by other programmes from the same department*’’.

Maintenance as a sub-theme; the researcher observed that during the intervention the blower kept failing due to continuous use by different groups of students. Nilsson (2011) in his 5T Theory, Trust, Tutor, Tasks, Time and Tools points out that hands-on training, especially in foundry workshops where inadequacy of any of the 5Ts affects the delivery of TVET. The development of a maintenance plan was another way of increasing equipment availability. The students and one technician identified two machines commonly used which included the furnace and CNC milling machines. Under preventive maintenance, a history card was drawn indicating how often the blower on the furnace breaks down and the major fault being wearing out of carbon brushes. In addition to that, the technicians and students organized the workshop which increased space and safety.

4.4.2 Results from Assessment tool

Evaluation feedback back collected from students that presented their patterns and were assessed based on identified attributes of sound patterns are presented in Table 13. The researcher observed the participation of students in their respective groups. Artefacts such as patterns and pattern drafts were presented that showed students’ reflections on the activities done which are in line with the theory of situated learning that informed the study. The researcher developed an assessment tool that was used to measure the competence of students during the process of pattern-making and the artefacts based on pattern attributes. The results from the assessment tool are presented in Table 13.

Table 13: Results of the assessed groups

Group	Considerations						Total
	Product /5	Draft /15	Presentation Process/30	Dimensions With Allowances /20	Rounded corners/edges/10 No sudden change in dimension /10	Smooth Surface finish/10	
1.	5	12	25	15	20	9	87
2	5	12	25	15	20	7	84
3	5	10	20	10	10	7	62
4	5	10	28	15	20	7	80
5	5	10	28	10	15	9	87

Source: Primary data

Table 13 shows five groups that participated in the presentation of the patterns made during the study and they were assessed based on the three major attributes; rounded corners, surface finish, and dimensions measured on the final pattern with allowances as indicated on the pattern draft. The results indicated that students' competencies in pattern making improved as they made patterns while reflecting on the effects such as failure to add allowances on final product dimensions, poor surface finish and sudden change in shape on the final casting. This is in line with the situated learning theory that guided the study. The group with the least marks was due to inadequate measuring skills that affected the final product. To avoid defects associated with poor pattern making such as dimensional inaccuracy, the group had to repeat the exercise with guidance from the technician. Figure 15 shows one group of students presenting their pattern to technicians. patterns and pattern drafts are in Appendix XIV and Appendix XV.

Figure 15: One group presenting their pattern

Source: Primary data. 2021

4.5 Discussion of results

The researcher discusses the results of the findings presented in this section. The discussion of the results depended on the interpretation and description of the processes based on the researcher's experience and reflection of the pattern-making process and also on the perception and views of the participants in this study. In this discussion, the researcher incorporated related views and theories from various scholars to back up the analysis of the results.

4.5.1 Gaps hindering students' competence development in foundry practice at DMPE

The findings revealed that some of the gaps hindering students' competence development in foundry practice at DMPE include; Inappropriate method of assessment, failure to cope with the changing technology, more theory work than practice, large students' enrolment; inadequate training facilities and equipment.

Inappropriate method of assessment; During focus group discussion, the researcher observed that foundry technicians assess the final product instant of the process of production. From the researcher's point of view, assessing the final product retards students' confidence and competencies while carrying out projects, however, this could be due to low emphasis on practical training and inadequate time to handle large numbers of students. Wettaka (2018) points out students perform practical exercises not for skills development but rather for coursework assessment.

Failure to cope with the changing technology; During focus group discussion, students said that modern technology is a key aspect of the changing world. From the researcher's point of view, technicians should be attached to industries for more pedagogical skills and practical knowledge for students' competence development. This is in line with Olema (2018) who points out that field study exposes students to an industrial environment in addition to the use of ICT. The changing world is full of new technology and skills that students are to be equipped with for effective performance and competence in the world of work (Esenina et al, 2019).

Inadequate training resources; During the future workshop, students presented inadequate training facilities and equipment for foundry practical work. A student said there are inadequate training materials as compared to the number of students that attend a practical session which disrupts their concentration during practical sessions. On the other, technicians resort to teaching theory and grouping students in groups of ten with delayed feedback and low content coverage. Inadequate content coverage is a recurrent gap in training most practical course units (Bogere 2016; Kintu & Aheisibwe, 2019). They believe the main cause of low competence development is adequate time allocated for practical work which leads to low content coverage.

4.5.2 Interventions to enhance competence development in foundry practice at DMPE.

The findings revealed that the various interventions to enhance students' competence development in foundry practice at DMPE included**;** rescheduling foundry practical sessions, equipment and space availability, use of group learning and advocating for accessibility to DMPE foundry workshops.

Rescheduling foundry practical session; The findings showed that foundry practical sessions were scheduled for 2 hours on the timetable and there were lectures immediately after them. Despite the tight schedule, the students were willing to work during their resting time. Students suggested that practical lessons would be scheduled after break time. The students pointed out that after break time there were two hours which would allow extension of time to those that need to complete their assignment without extending the time for the next lecture and this would lead to timely feedback, particularly during project work. This is in line with Kintu and Aheisibwe (2019) who indicate that feedback is managed for large groups where adequate time is scheduled. The researcher observed that there was a need for rescheduling practical time to allow students to complete their practical work, and receive immediate feedback and assessment of the process taken during the production of artefacts.

Use of group learning; The findings in Table 10 revealed that the use of small group learning where the students were organized in manageable groups of five showed that students actively participated during practical sessions in their respective groups and they got immediate feedback. Small group learning allows project-based learning to take place with the full participation of students (Taitira, 2013). At the DMPE, group learning was being used however, the maximum number of students in a group was 10 which made some students redundant. Group learning allows students to participate actively in practical work and to become team leaders (Mintah, 2014). Kikoyo (2020, pg. 31) pointed out that group discussions allow maximum student ability to construct knowledge. However, the researcher observed that time could not allow full content coverage. Therefore, this strategy requires maximum participation and commitment of both students and technicians for competence development.

Equipment and space availability; The findings in table 11 revealed that there was a need for equipment availability and space due to the large number of students who lose concentration during practical work sessions. This is in agreement with Nilsson (2011) who pointed out that inadequacy of equipment as one of the elements in his 5T theory hinders competence development. Technicians are forced to teach practical work using the lecture method (Kemevor and Kassah (2016) instead of demonstration.

Advocating for accessibility to DMPE; The finding on accessibility to workshop revealed that the intervention increased students' participation and reflection due to the challenges involved that required experiences from the technician as he guides the student. On the other hand, one technician revealed that the costs involved in engaging in these activities were high in terms of electricity bills. Another technician in the focus group discussion revealed that clients did not have confidence in students due to delays in delivery of work, material and time wastage. However, the researcher subjectively believes students become competent only when they try and fail and try again (Mjelde,2013). The ability to perform tasks comes with built confidence from continued practice in real-world activities.

(Khandelwall et al 2014). This is in agreement with Bita (2020) who points out that Iganga Technical Institute acquired modern Automotive equipment that aid competence development in students as they continuously practice on real-life activities. This is further in line with Kintu et al (2019) as mentions that real-life activities voluntary participation of students with the major reward being development competences needed in world of work.

4.5.3 Implemented interventions to enhance competence development in foundry practice at DMPE.

The identified interventions were implemented as indicated in Table 6 such as the administrators changing foundry technology practical session after break time. In addition, several other interventions as recommended in the study were implemented among others which included the HoD allowed the utilization of workshops by technicians and students on community work. Students were taught using group learning in manageable groups that aided immediate feedback. The researcher collected data from the implementation of the identified interventions that enhance competence development, and implemented interventions that involved activities such as; an increase in practical time by rescheduling practical time after break time and; the use of group learning in groups of five maximum students per group to minimize redundant students. The researcher used focus group discussion, interview guide and observation checklist to gather relevant data. Interventions were identified in the future workshop.

4.5.4 Evaluation of the impact of strategies implemented

Under this theme, the researcher discusses the findings from the evaluation tool and competence evaluation tool. The project was implemented successfully. Competence-based assessment is known to technicians however due to the large numbers of students they ended up not using it. During the evaluation meeting the stakeholders said that there is a need to enhance competence in foundry practice using the three interventions; small group learning (group learning builds confidence and teamwork); accessibility to community activities (increases participation and reflection), rescheduling time for increased time (allows for feedback, participation and reflection). On the other hand, networking much as it increased equipment and space availability, but one technician discouraged it by mentioning that it was administrative. However, one technician mentioned that they tapped new ideas from experienced technicians. The researcher subjectively believes that working as a team in the era of changing technology builds confidence in both technicians and students which is in agreement with Esenina, Blinov and Satdykov (2019) who stated that internal networking is resourceful to technicians.

The competence evaluation tool indicated that students gained competence to a greater extent from the identified interventions. Technicians mentioned that through the presentation of the process of how the product was done and the product, students were able to answer why certain attributes were emphasized in the pattern. From the focus group discussion, a student said assessing the process made them internalize the concept better than just handing in the product for assessment. This is in line with the Ministry of Education and Sports (2019) which states that assessment should be done on the process, not on the final product.

CHAPTER FIVE: SUMMARY, CONCLUSIONS, RECOMMENDATIONS

5.1 Summary

The purpose of the study was to explore strategies that enhance students' competencies in foundry practice at DMPE. The specific objectives of the study were to examine gaps hindering students' competence development in foundry practice at DMPE, identify interventions aimed at enhancing students' competence development in foundry practice at DMPE; implement the identified interventions aimed at enhancing students' competence development in foundry practice at DMPE and evaluate the impact of the implemented interventions aimed at enhancing students' competence development in foundry practice at DMPE. The method used in the study was situation analysis, which involved the work process and future workshop procedures. Evaluation of the implemented strategies was done by use of an evaluation tool administered to students and teaching staff. In addition, students presented their final product and an assessment tool was used to assess their competence.

Findings from the evaluation of the implemented strategies indicated that students rated group learning highest followed by space and equipment availability and rescheduling practical sessions after break time while accessibility to the workshop to carry out real-life activities was rated lowest. The technicians rated group learning and accessibility to the workshop to real-life activities as both being relevant in developing students' competencies followed by rescheduling practical sessions after break time. While space and equipment availability ranked lowest.

The competence evaluation tool indicated that students gained competence to a greater extent from the identified interventions. Technicians mentioned that through the presentation of the process of how the product was done and the product, students were able to answer why certain attributes were emphasized in the pattern. From the focus group discussion, a student said assessing the process made them internalize the concept better than just handing in the product for assessment.

5.2 Conclusion

Based on the findings and evaluation of the implementations carried out the following conclusions are made;

There were several gaps hindering students' competence development in foundry practice at DMPE such as inadequate training materials, inadequate coverage of content, limited time allocated for practical work, inappropriate assessment method, low students' participation in practical work and emphasis on theory more than practical work These affected student's competence development in foundry practice coupled with the changing technology.

Several interventions were put in place to overcome the gaps that hinder students' competence development in foundry practice such as; rescheduling practical sessions, networking with technicians and developing of maintenance plan for equipment and space availability, use group learning technique and advocating for accessibility to DMPE workshops to carry out real-life activities. Despite all the interventions, assessment being done on the process rather than the final product posed challenges such as being time-consuming. Technicians confirmed the need for more time to supervise all students. while guiding the entire process. Therefore, implementing foundry practical work requires close supervision of students for immediate feedback. There was a need to give immediate feedback to build students' confidence and this was wrapped up at the presentation stage when students presented products that indicated development in competencies with safety considerations.

Competence development in foundry practice was necessary for students and the entire community as it would make them learn and understand the theory of situated learning. This would also help students to be competent, innovative, cooperative and creative. The competence developed would make students practice and make use of the skills, and knowledge they have acquired to benefit themselves and the community. The knowledge and skill would help them develop problem-solving skills. Competence development in foundry practice should therefore continue to be practised alongside content or theory lessons. The action research study was conducted appropriately where the teaching staff, administrators and students participated in developing competencies within foundry practice that lead to competence-based assessment rather than summative assessment. Many of the items produced are made to meet the demands of the community. Students were instructed by technicians to develop competencies in foundry practice to meet the demands of the community in the world of work coupled with the changing technology although the people did not trust the students due to wastage of materials. But this exposed many students to build confidence and develop competence in the work they make.

Conclusively, therefore, competence-based assessment is key to enhancing students' competence development at DMPE and in the world of work. The study observed that emphasis was put on three of the interventions such as; small group learning, accessibility to community activities and rescheduling practical sessions to acquire competencies by students who are the key trainees. The technicians observed that for effective development of competencies, the administration should emphasize close supervision and follow-up of students as the assessment tool at DMPE, industry and the world of work. The technicians revealed that the above strategies work hand in hand to develop competencies of students through trying and failing and trying again while considering the concept of active participation and reflection as key aspects in foundry practice.

5.3. Recommendations

Participation and reflection are key if students' competencies in foundry practice are to be developed. Participation can be achieved by the use of more than one strategy. Such strategies include; group learning with at least 5 group members, working on real-life activities brought by the communities and ensuring adequate space and equipment. Recommendations were drawn from the generated conclusion as follows;

5.3.1 Recommendation to students

For effective group learning as a strategy of enhancing students' competencies, students should actively participate in foundry activities in small manageable groups and should as well take on leadership roles for accountability of their group members during presentations of final products.

5.3.2 Recommendations to teaching staff

Teaching staff should develop a library of patterns to allow for further modifications and motivation of students. In addition, teaching staff together with students should come up with designs of components which can generate income for the institution and further set up foundry exhibitions to advertise those products hence encouraging creativity among technicians.

Technicians should give students project work which in turn will help in attaining skills at different foundry stages. Close supervision and assessment of the entire foundry process rather than waiting for the final product to ensure that the students attain the competencies needed in the world of work.

5.3.3 Recommendation to Administration

Support from administration to facilitate upgrading of foundry technicians for more skills.

Use of technology advancement in foundry technology since it comes with advantages of reduced foundry hazards and scores time. More technicians should be trained to guide students on several practical lessons. In addition, recruiting more teaching staff in the foundry workshop could be of added advantage since the number of students is big compared to the number of technicians.

Administrators should advocate for a foundry shop built in a larger space with safety considerations such as a good foundry layout with clear exits and more updated foundry machines such as melting furnaces and heat treatment facilities. The foundry workshop needs to be independent of other workshops to ensure proper practice and facilitate enough research.

The administration should carry out a maintenance plan with emphasis on preventive maintenance emphasized to ensure equipment availability.

Carrying out real-life activities brought by the communities greatly enhances the students' skills, knowledge and productivity due to the different engineering challenges encountered and the confidence developed as the students keep practising. In addition, the invitation of guest technicians enriches students' knowledge and reflection skills in real-life activities.

5.3.4 Area for further research

Other areas for further research include studies on;

i. Relationship between training equipment availability and production of self-sustaining foundry graduates.

ii. Relationship between the technicians' industrial competencies and production of self-sustaining foundry graduates to relate theory with rapid technology advancement.

iii. Enhancing students' competencies in foundry practice through the use of Information Communication Technology (ICT) especially pattern designs.

REFERENCES

Achieng, N.R., (2012). Master's thesis on factors affecting acquisition of vocational skills among youth learners in Maranda division Siaya county.

African Development Bank Report, (2020). Uganda - Support to Higher Education, Science and Technology (HEST) Project. Accessed on 30th September 2021.

Anaele, S., & Ogundu, I. (2020). Foundry Skills Required of Mechanical Craft Practice Students for Entrepreneurship Development in Technical Colleges in Rivers State. *International Journal of Modern Innovation and Knowledge*.

Anindo, I., Mugambi, M., & Matula, D. (2016). Training equipment and acquisition of employable skills by trainees in public technical and vocational education and training institutions in Nairobi County, Kenya. Training.

Arinaitwe, D. (2011). Master's Degree in Vocational Pedagogy on Vocational Pedagogy Approaches for the improvement of teaching and learning in formal vocational education in Uganda: A Case Study at Kyambogo University: Faculty of Technical and Vocational Teacher Education, May 2011.

Arinaitwe, D. (2021). Practices and strategies for enhancing learning through collaboration between vocational teacher training institutions and workplaces. Empirical Research in Vocational Education and Training, 13(1), 1-22.

Arinaitwe, D. N. (2020). Doctoral dissertation on Investigation of Flexural Strength of Reinforced Concrete Beams in Rwanda.

Atchoarena, D., and Delluc, A. (2001). ‘Revisiting Technical and Vocational Education in sub-Saharan Africa: An Update on Trends, Innovations and Challenges. Paris: UNESCO, IIEP

Ates. O and Eryilmaz A, (2011). Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards physics Asia-Pacific Forum on Science Learning and Teaching, Volume 12, Issue 1, Article 6, p.1.

Azizi, N., (2015). People Skill Empowerment Towards Sustainable Employment: An Integrated and Community-oriented TVET Framework for Rural Areas in Iran Conference Paper · https:/www.researchgate.net/publication/326633355 Nematollah Aziz uploaded July 2018.

Bandura, A. (1986). Social foundations of thought and action. Englewood Cliffs, NJ, 1986(23-28).

Beerley P. (2001) Foundry Technology 2nd edition. ISBN 0 7506 4567 9

Benazir Y. B (2014) Investigating the competency mapping among the operators in an auto component organization. Sri Krishna College of Technology. Research paper Vol 2 issue 2 ISSN 2347-1697 International Journal for Informative and Futuristic Research. https://www.researchgate.net/publication/318094646 Y. Benazir Bena on 02 July 2017.

Bertram, D., (2013). Likert Scale are the meaning of life. CPSC 681-Topic.

Bita. G., (2020). New vision paper of 13th May 2020 p.18

Bogere M. P (2016) Improving learners practical training and skills acquisition in production technology at the department of mechanical and production engineering. Kyambogo University.

Burns A., (2015) Action research. Chapter eleven· January 2001

Bwana, W. M. (2018). Liberalization of university education and the learning environment in public universities in Uganda: a case study of Kyambogo University (Doctoral dissertation, Kyambogo University).

Campbell, J. (2015). Complete casting handbook: metal casting processes, metallurgy, techniques and design. Butterworth-Heinemann.

Clinton I, Godstime, C, T & Chukuladi U, P. (2022). Relevant Foundry Craft Practice Skills for Technical College Students' Self-Employment in COVID-19 Pandemic Era in Rivers State. Asian Journal of Education and Social Studies 27(4): 1-8, 2022; DOI: 10.9734/AJESS/2022/v27i430659.

Coghlan, D. (2019). Doing action research in your own organization. Sage.

Connelly, L. M. (2014). Ethical considerations in research studies. *Medsurg Nursing*, *23*(1), 54-56.

Creswell, J. W. (2003). Research design 2nd edition. Sage publications.

Creswell, J. W. (2014). Qualitative, quantitative and mixed methods approach. Sage

Donato. D. D., (2019). Definition of Hands-on Training. (August; 2019).

Egau, J. O., & Humphrey, H. (2002). Meeting the challenges of Technical\Vocational Education: The Uganda Experience Retrieved from Kampala: http://www.personal.psu.edu/users/j/o/joe102/publications/voced.pdf

Esenina.E., Blinov. V., Satelykov. A., (2019) Applying the G20 Training Strategies – Approaches. A partnership of ILO and Russian. Approaches to developing competency-based VET programs stock testing technologist.

Farrant, J.S. (2002), Principles and practice of education, new edition, Longman groups, U.K Ltd. United Kingdom.

Gary R. Sisson (2009) Hands-on Training: A simple and effective method for On-the-Job Training. Published by Berrett-Koehler publisher. www.bk connection.com.

Green, C., Eady, M., & Andersen, P. (2018). Preparing quality teachers. Teaching & Learning Inquiry, 6(1). http://dx.doi.org/10.20343/teachlearninqu.6.1.10

Guma T.N & Ogboi I.U (2019) A typification of foundry practices for corer artisanal sand casting of the aluminium pot. International Journal of Engineering Applied Sciences and Technology. Vol.4 issue 4.

Haury, D. L., & Rillero, P. (1994). Perspectives of Hands-On Science Teaching.

Herfurth, K., & Scharf, S. (2021). Casting. In Springer Handbook of Mechanical Engineering (pp. 325-356). Springer, Cham.

Hoffmann, T. (1999). The meanings of competency. *Journal of European Industrial Training*, *23*(6), 275-285. https://student.oslomet.no/documents/585736/47012502/Brosjyre+KyU+2018/961821d9-5c5c-916e-92e5-9a546be0cdf2

Hughey, M. (2020). Appendix B. Research Methodology. In White Bound (pp. 209-222). Stanford University Press. ISBN 978-0-521-66363-2

Jain R.K (2001). Production Technology Khanna publishers.

Jungk, R. & Müllert, N. (1987). *Future Workshops: How to Create Desirable Futures.* London: Institute for Social Inventions.

Kemevor and Kassah (2016). Challenges of Technical and Vocational Education and Training and Educational Stakeholders in the Volta Region of Ghana International Journal of Humanities Social Sciences and Education (IJHSSE).

Khandelwal, H., & Ravi, B. (2014). Tabletop foundry for training, research and small enterprises. Indian Foundry Journal, 7(2), 23-29. [online] retrieved from https://www.researchgate.net/publication/273442972 VOL 60 NO,2 Feb 2014

Kikoyo B, Kato. H. Kizito, M. (2020). Investigation into the teaching and learning process towards enhancing learning; a case study of mechanical and production engineering department, Kyambogo university. July 2020 international journal of research and methods in education. DOI: 10.9790/7388-1003020614.

Kikoyo. B. (2017) improving teaching and learning processes in computing for mechanical engineers: A case of Department of Mechanical and Production Engineering, Kyambogo university. Master’s thesis.

Kintu D, Mashtakh Kisilu. K, and Ferej A. (2019) An Exploration of Strategies for Facilitating Graduates’ Transition to the World of Work: A Case of Technical, Vocational Education and Training Graduates in Uganda. *International Journal of Vocational Education and Training Research*. Vol. 5, No. 1, 2019, pp. 1-9. Doi: 10.11648/j.ijvetr.20190501.11

Kintu, D & Aheisibwe.I. (2019). Exploring the Effectiveness of Informal Apprenticeship in a Community of Practice: A Case Study of Katwe, Kampala-Uganda. African Journal of Teacher Education, 8. https://doi.org/10.21083/ajote.v8i0.5353

Kumar, R. (2011). Research Methodology: A step-by-step guide for beginners (3rd ed.): Sage.

Kyambogo University. (2009). Programme for Master's Degree in Vocational Pedagogy. Kampala: Harambee Publishing.

Kyambogo University. (2015). Revised BEMME programme book.

Langkos. S. (2014). Chapter 3 - Research Methodology: Data collection method and Research tools. https://www.researchgate.net/publication/270956555 DOI:10.13140/2.1.3023.1369.

Lave, J and Wenger, E. (1991). Situated learning. Legitimate peripheral participation. ISBN 978-0-521-41308-4

Lewin, K. (1946). Action research and minority problems, Journal of Social Issues 2(4).

Lind berg, V. (2003). Learning Practices in Vocational Education. Scandinavian Education Research, 47(2), 157-179.

Lucas, B. (2014) Vocational pedagogy: What it is, why it matters and how to put it into practice. Report of the UNESCO-UNEVOC virtual conference Moderated by Bill Lucas. International Centre for Technical and Vocational Education and Training www.unevoc.unesco.orgunevoc@unesco.org ISBN 978-92-95071-72-8.

Lucas, B., Spencer, E., and Claxton, G (2012). *How to teach vocational education: a theory of vocational pedagogy*. London: City & Guilds. This paper draws substantially on work commissioned by City & Guilds.

McNiff, J. (2002) Action Research: Principles and Practice. London: Routledge. *A seminal text that established new principles of thinking and a tradition of academic writing for everyday practitioners.*

Ministry of Education and Sports (2012). Skilling Uganda, BTVET Strategic Plan 2011-2020. Kampala: Ministry of Education and Sports.

Ministry of Education and Sports (2015). National Curriculum Development Centre (NCDC).

Ministry of Education and Sports (2019). The Technical and Vocational Education and Training (TVET) policy.

Mintah K.E., (2014). Using group method of teaching to address the problem of large class size: action research.

Mishra, L. (2016). Focus group discussion in qualitative research. *Techno Learn*, *6*(1), 1. work experience.

Mjelde, L. (2006). Magical Properties of Workshop learning. Studies in Vocational and Continuing Education. Bern: Peter Lang.

Mjelde, L. (2013). Handbook for Masters students in vocational pedagogy. Equality, Complementarity, Solidarity and Fidelity. Harambe publishing.

Mjelde, L. (2017). Learning through praxis and cooperation: Lev Vygotsky and vocational pedagogy. In F. Murhuenda-Fluixa, Vocational education beyond skill formation. (pp. 1-22). Bern: Peter Lang.

Mjelde, L., & Daly, R. (2012). Aspects of vocational pedagogy as practice: Decolonizing minds and negotiating local knowledge. International Journal of Training Research, Vol. 10: 1, 43-57. DOI: https://dx.doi.org/10.5172/ijtr.2012.10.1.43

Mills, G. E., (2011). Action Research. A Guide for the Teacher Researcher (Fourth Edition). Pearson Education Inc.

Morris, J. (2016). Introduction; Group work. University of Oregon

Muganga, L., & Ssenkusu, P. (2019). Teacher-Centered vs. Student-Centered: An Examination of Student Teachers' Perceptions about Pedagogical Practices at Uganda's Makerere University. Cultural and Pedagogical Inquiry, 11(2), 16-40.

Mugenda, O. M., & Mugenda, A. G. (2003). Research Methods: Sample size determination. *African Centre for Technology Studies*.

Nabaggala, J., (2015) The dreamscape and meaning of work in vocational education and training: A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy Department of Secondary Education University of Alberta.

Nilsson, L. (2011). Vocational Education. A Historical Analysis: Vocational Didactics. Sweden: University of Goteborg

Nugent, G, Malik. S., & Hollingsworth. S., (2012) A practical Guide to Action Research for Literacy educators. https://www.researchgate.net/publication/282199978

Obwona .M, Shinyekwa. I, Kiiza J., Hisali. E., (2013). The Evolution of Industry in Uganda: Presented at the Learning to Compete Conference: Industrial Development and Policy in Africa in Helsinki, Finland June 24th to 25th 2013.

Ocampo R. & Vos (Eds), (2008). Uneven Economic Development, London: Zed Books.

OECD, (2009)., Teaching Practices, Teachers' Beliefs and Attitudes. Creating Effective Teaching and Learning Environments: ISBN 978-92-64-05605-3

Oketch. M., (2014). Education policy, vocational training, and the youth in Sub-Saharan Africa 2014, March: WIDER Working Paper 2014/069: World Institute for Development Economics Research wider.unu.edu

Olema, V. (2018). Complexities and Contradictions to Vocational Education and Training: A case of Uganda) preprint January 2019 Doi: 10. 13140/RE, 2.2.19859. 53286. http://www. Research gate. Net. Peace engineering conference.

Oliver, R., and Herrington, J., (2000). Using Situated Learning as a Design Strategy for Web-Based Learning Chapter XI UPLOADED 2014 · DOI: 10.4018/978-1-878289-59-9.ch011 https://www.researchgate.net/publication/229439467

Otage, S. (2014). Five decades of growing a metal casting business. Tuesday September 9th 2014 Daily monitor by Stephen Otage online jbkirabira@tech.mak.ac.ug

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K, (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and policy in mental health and mental health services research, 42(5), 533-544.

Rance-Roney, J.A. (2010). Reconceptualizing interactional groups: Grouping schemes for maximizing language learning. *English Teaching Forum, 48*(1), 20-26. Retrieved from http://americanenglish.state.gov/files/ae/resource_files/10-48-1-d.pdf

Rao, R.T.V. (2004). Metal Casting principles and practice.

Rao, T. R. (2007). Metal casting: Principles and practice. New Age International.

Safe work Australia (2013). Guide to managing Risks Associated with foundry. work.www.Swar.gov.au

Sajedi, S.P. (2014). Collaborative summary writing and EFL students' L2 development. *Social and Behavioural Sciences*, *98*, 1650-1657.

Sannerud, A. R. (2019). Vocational pedagogy. Sharing Knowledge Transforming

Societies. [online] retrieved from https://library.oapen.org/bitstream/handle/20.500.12657/23442/Sharing_Knowledge_Transforming_Societies_web_ss.pdf?sequence=1#page=272 accessed on 30th September 2021

Schmidt D., (2015). Hands-on training; Tips and Tools May 2015 presentation Notes sample instructor Guide.

Sharma P.C (2001). A textbook of Production Technology (Manufacturing Processes) Ed 3: publisher S. Chand and Company Ltd.

Srinivasan, N.K. (2000). Foundry Engineering.

Srinivasan, N.K. (2012). Foundry Engineering, 4th edition.

Tatira L (2013). Employing Group Method as a Way of Teaching: A Continuation of What Obtains in Society. *International Journal of Academic Research in Progressive Education and Development January 2013, Vol. 2, No. 1 ISSN: 2226-6348*.

Titeca, K. (2019). Uganda: Museveni's struggle to create legitimacy among the 'Museveni babies. *liberation*, *38*(10), 2347-2366.

Turner, D. W. (2010). Qualitative Interview Design. A practical Guide for Novice Investigation. The Qualitative Report, 15(3),754-760. http://nsuworks,nova.edu/tqr/vol15/iss3/19.

Uganda Country Report (2014) Eastern Africa's Manufacturing Sector: Promoting technology, innovation, productivity and linkages: November 2014 Published by: African Development Bank Group – Eastern Africa Regional Resource Centre (EARC) Khushee Tower Longonot Road, Upper Hill Nairobi, Kenya

Uganda Government (2013). Uganda Vision 2040, National Planning Authority.

Vavoula, G, N. and Sharples M., (2007). Future Technology Workshop: A Collaborative Method for the Design of New Learning Technologies and Activities (preprint)

Vidal, R. V. V. (2006). The future workshop: Democratic problem-solving. Economic analysis working papers, 5(4), 21.

Villar, A., Arribas, J. J., & Parrondo, J. (2012). Waste-to-energy technologies in continuous process industries. *Clean Technologies and Environmental Policy*, *14*(1), 29-39.

Wasswa, I., (2020). Museveni commissions skills training centre in Namanve, second opinion paper of 16th January 2020, pg. 387 0f 908.info@SecondOpinion.co.ug.

Wenger, E (2008). Communities of practice: Learning, meaning, and identity.

Wettaka, J. (2018). Improving hands-on training for skill acquisition of engineering students at the Department of Mechanical and Production Engineering, Kyambogo University Master's thesis.

Winch, C. (2004). Education, work and Social Capital: Towards a new conception of vocational education (a response to Richard Barrett). Studies in Philosophy in education.

Witkin, B.R., & Altschuld, J.W., (1995). Planning and conducting needs assessments. A practical guide. Sage.

World Bank Report (2011). Science, technology and innovation in Uganda: Recommendations for Policy and Action, Washington, DC: World Bank.

Wrenn, J. and Wrenn, B. (2009). Enhancing Learning by Integrating Theory and Practice *International Journal of Teaching and Learning in Higher Education* 2009, Volume 21, Number 2, 258-265 http://www.isetl.org/ijtlhe/ ISSN 1812-9129.

Zoncita D. N., (2015). Situated Learning: A Legitimate Peripheral Participation in Learning Mathematics in Public Schools, (Doctoral Program in Leadership Studies Gonzaga University October 13, 2015 (Revised: December 12, 2020.

APPENDICES

Appendix 1: Letter of Introduction to DMPE

KYAMBOGO UNIVERSITY
P. O. Box 1 Kyambogo, Phone: 041-285001/2 Fax: 041-220464
www.kyambogo.ac.ug
FACULTY OF VOCATIONAL STUDIES
DEPARTMENT OF ART & INDUSTRIAL DESIGN
MASTERS IN VOCATIONAL PEDAGOGY PROGRAMME

15th September, 2018

…………………………………………………………………………

…………………………………………………………………………

RE: INTRODUCTION OF NAMUTEBI MADINAH DINAH.

This comes to introduce to you NAMUTEBI MADINAH Dinah a student of Masters in Vocational Pedagogy (MVP) Programme at Kyambogo University. This student bears registration no. 17/U/14858/GMVP/PE and in her final year. As a requirement for graduation, this student is expected to carry out Action Research through a collaborative process with World of Work.

Any support rendered to her is highly appreciated.

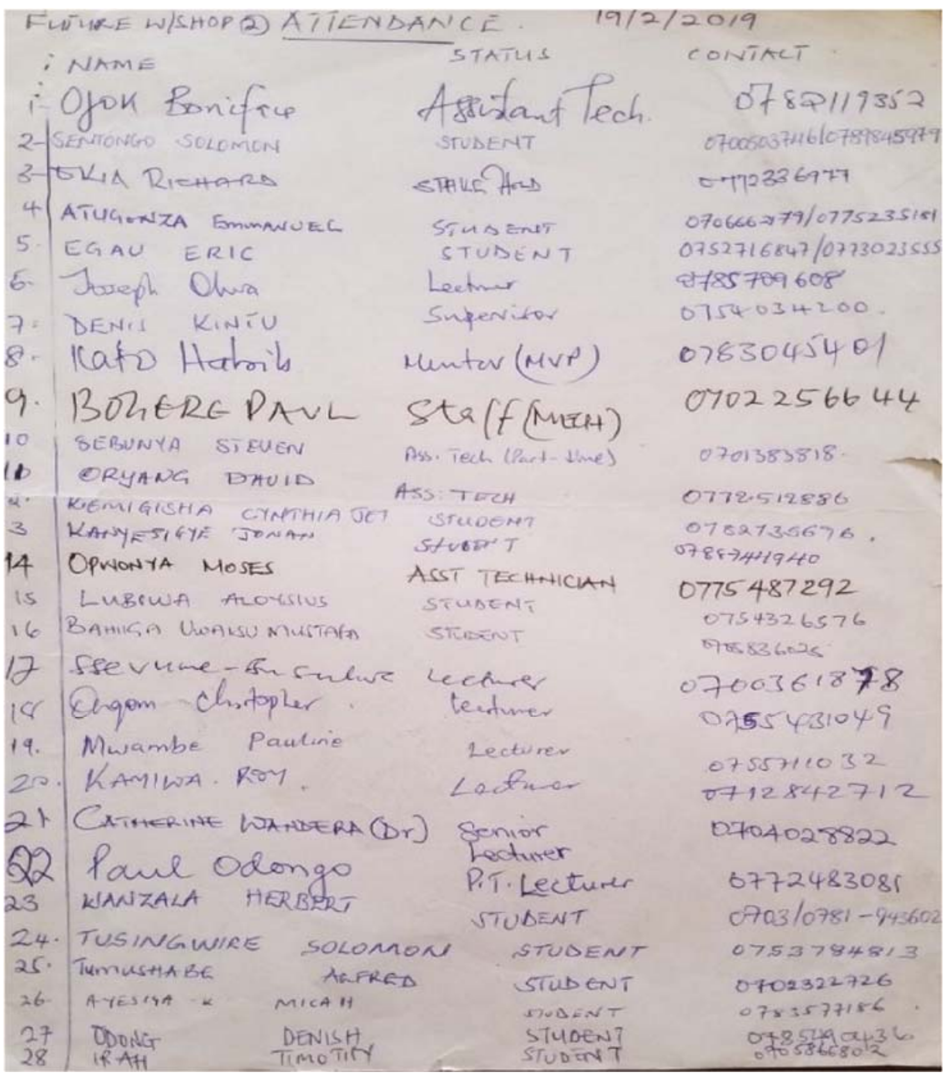
Looking forward to your usual support.

Yours Sincerely,

P/ **Chris Serwaniko**
Project Coordinator, NORHED MVP Project
Masters in Vocational Pedagogy Program

Appendix II: Future workshop carried out at DMPE staffroom

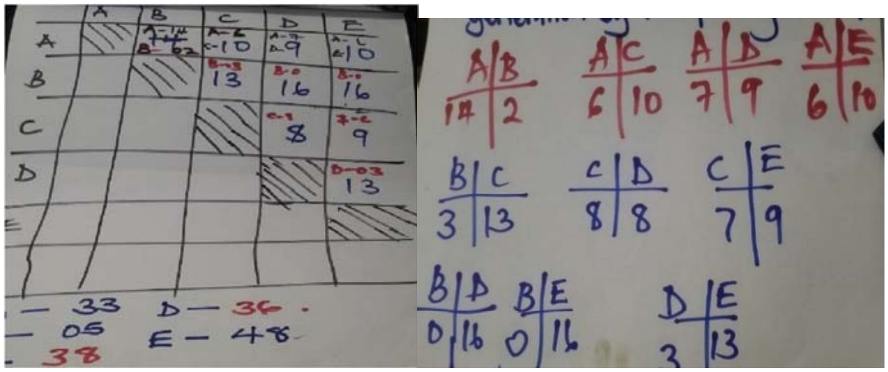

Appendix III: Attendance list for future workshop



FUTURE W/SHOP (2) ATTENDANCE. 19/2/2019

	NAME	STATUS	CONTACT
1.	Ojok Boniface	Assistant Tech.	0782119352
2	SENTONGO SOLOMON	STUDENT	0700503716/0789845979
3	OKIA RICHARD	STAKE HOLD	0772336977
4	ATUGONZA EMMANUEL	STUDENT	070666279/0775235181
5.	EGAU ERIC	STUDENT	0752716847/0773023555
6.	Joseph Olwa	Lecturer	0785709608
7.	DENIS KINTU	Supervisor	0754034200.
8.	Kato Habib	Mentor (MVP)	0783045401
9.	BOZERE PAUL	Staff (MECH)	0702256644
10	SEBUNYA STEVEN	Ass. Tech (Part-time)	0701383818.
11	ORYANG DAVID	ASS: TECH	0772512886
12.	KEMIGISHA CYNTHIA JET	STUDENT	0782735676.
13	KANYESIGYE JONAN	STUDENT	0788744940
14	OPWONYA MOSES	ASST TECHNICIAN	0775487292
15	LUBWA ALOYSIUS	STUDENT	0754326576
16	BAHIGA UWAISU MUSTAFA	STUDENT	0758836025
17	Ssevume-Sensulwe	Lecturer	0700361878
18	Ongom Christopher	Lecturer	0755431049
19.	Mwambe Pauline	Lecturer	0755711032
20.	KAMIWA. ROY.	Lecturer	0712842712
21	CATHERINE WANDERA (Dr)	Senior Lecturer	0704028822
22	Paul Odongo	P.T. Lecturer	0772483081
23	WANZALA HERBERT	STUDENT	0703/0781-943602
24.	TUSINGWIRE SOLOMON	STUDENT	0753784813
25.	TUMUSHABE ALFRED	STUDENT	0702322726
26	AYESIGA -K MICAH	STUDENT	0783577186
27	ODONG DENISH	STUDENT	0785290436
28	IRAH TIMOTHY	STUDENT	0705866802

Appendix IV: Pairwise ranking process and results



Appendix V: Action plan for the identified strategies.

S No	Activities	Person responsible	Time frame	Indicators
1	Rescheduling practical sessions after break time to increase practical time.	HOD	Beginning of semester, I final copy 2020/2021	Adjusted time table
2	Space and equipment availability by; - Networking with technicians from DCBE and DMPE. – Preparation of maintenance plan.	HOD, Technicians, lead researcher	30th March 2020 Onwards	Introduction letter to technicians in civil department. Maintenance plan for furnace and CNC machine.
3	Use of group learning for more hands-on activities	Technicians, lead researcher	30th March 2020 On wards	Attendance list of students, artefacts
4	Access to DMPE workshops to allow students to engage in real life activities brought by the communities	HOD, Technicians, students, Lead researcher.	30th March 2020 On wards	Students' attendance and Artefacts

Appendix VI: Introduction letter to DMPE from NOMA seeking permission to carry out Action Research

KYAMBOGO UNIVERSITY
P.O. BOX 1, KYAMBOGO
Faculty of Engineering
Department of Mechanical & Production Engineering

20th February 2020

Head of Department
Civil and Building Department
Kyambogo University

Dear Sir

RE: REQUEST FOR PERMISSION TO USE YOUR WORKSHOPS

I write to request you to grant permission to Ms Namutebi M. Dinah a staff in the Department of Mechanical & Production Engineering to conduct Action Research in your Department's Carpentry and the Mechanical Technological Workshops.

She has about 40 students to work with. The class will be divided into smaller units of 4 students per group.

I will highly appreciate if Ms Dinah gets assistance.

Thank you

Yours Sincerely

Dr. Titus Bitek Watmon
Head of Department
Mechanical and Production Engineering

HEAD OF DEPARTMENT MECHANICAL AND PRODUCTION ENGINEERING
KYAMBOGO UNIVERSITY
20 FEB 2020
P. O. BOX 1, KYAMBOGO

Appendix VII: Students carrying out pattern making processes during the implementation stage


Maintenance of key foundry equipment for melting by the researcher, colleague and foundry students


Group practicing pattern making from DCBE carpentry work shop with technician C.


Group carrying out melting from DCBE under supervision of Technician A and mechanical foundry workshop under supervision of technician B.

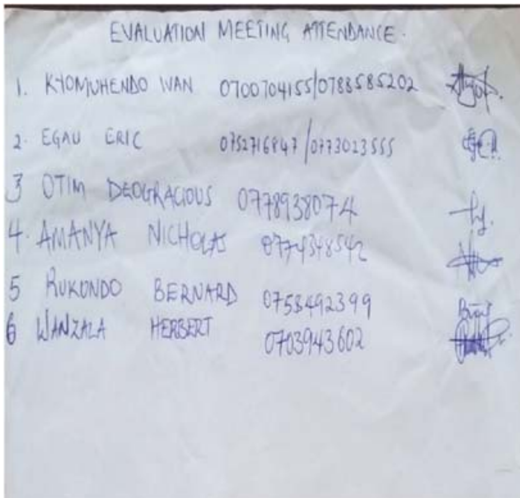
Groups making patterns under guidance of technician D and E.

Appendix VIII: Evaluation stage

Interview with Head of Department. Focus group discussion evaluation with students

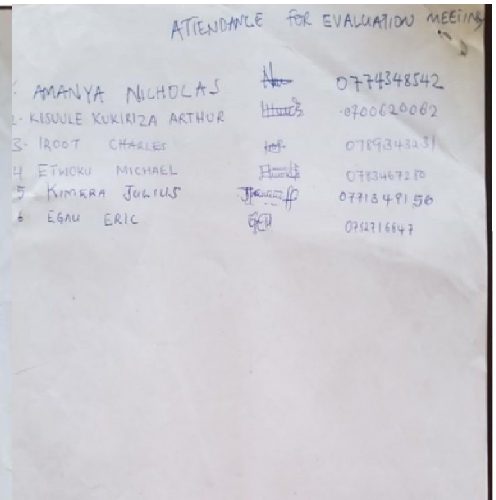
Students explaining pattern process to colleagues as researcher observes

Appendix IX: Attendance lists during evaluation meetings.



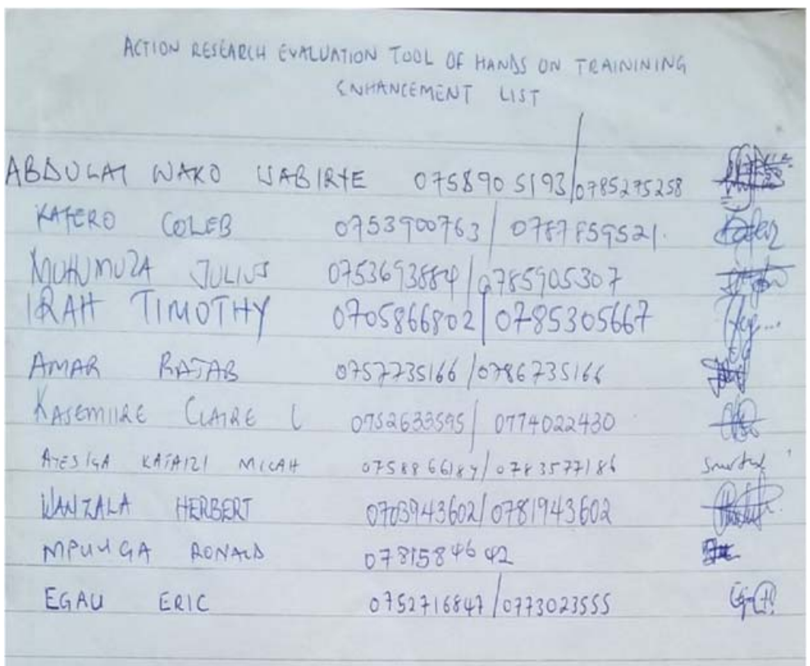
EVALUATION MEETING ATTENDANCE.

1. KYOMUHENDO WAN 0700704155/0788585202
2. EGAU ERIC 0752716847/0773023555
3. OTIM DEOGRACIOUS 0778938074
4. AMANYA NICHOLAS 0774348542
5. RUKUNDO BERNARD 0758492399
6. WANZALA HERBERT 0703943602



ATTENDANCE FOR EVALUATION MEETING

1. AMANYA NICHOLAS 0774348542
2. KISUULE KUKIRIZA ARTHUR 0700620082
3. IROOT CHARLES 0789343231
4. ETWORU MICHAEL 0783467210
5. KIMERA JULIUS 0771349156
6. EGAU ERIC 0752716847



ACTION RESEARCH EVALUATION TOOL OF HANDS ON TRAINING ENHANCEMENT LIST

ABDULAH WAKO WABIRYE	0758905193/0785275258
KATERO COLEB	0753900763/0787F59521
MUHUMUZA JULIUS	0753693884/0785905307
IRAH TIMOTHY	0705866802/0785305667
AMAR RAJAB	0757735166/0786735166
KASEMIIRE CLAIRE L	0752633595/0774022430
ATESIGA KATAIZI MICAH	0758866187/0783577186
WANZALA HERBERT	0703943602/0781943602
MPUNGA RONALD	0781584642
EGAU ERIC	0752716847/0773023555

Appendix X: Maintenance plan

	KYAMBOGO UNIVERSITY, DMPE FOUNDRY WORKSHOP MAINTAINANCE PLAN								
EQUIPMENT TYPE		**DESCRIPTION**			**LOCATION**	**DOCUMENT AVAILABLE**			**COST (Ugx.)**
Sheet Foundry workshop Equipment		**A maintenance plan for Kyambogo University DMPE foundry workshop**			**DMPE Foundry workshop**	**Supplier's delivery note**			
Item	**Maintenance task Description**	**Maintenance type**	**Freq. (days.)**	**Crafts men**	**Machine condition for breakdown maintenance**	**Procedure task**	**Estimated Task time(hours)**	**Special Tools**	
1. Pit furnace	Checking o cooling wat supply	Preventive	2	Students	Overheating of furnace	Add water in the cooling tank	10	Jerry can	20,000
	Cleaning furn area	Preventive	Daily			Remove ash & construct pit	1	Fire clay bricks	500,000
	Blower	Corrective	2	Technician	Non responsive switch Electrical fault.	Replace motor/consult electrician	1	Electric multi meter	200,000
		Preventive							
	Crucible	Corrective	1	Technician	Broken	Replace	1	Spare crucible	
		Preventive	Daily	Technician	Brittle crucible	Proper handling & storage		rack	
	Tongs	Corrective	1	Technician	Worn out/ don't hold crucible	Replace	1	Spare part	

2.CNC Milling machine		Preventive	1	Technician	Alarm check	Respond to signal notification, check program			
		Preventive	Daily	Technician	Parts fail to move	Clean off dust and oil		SAE 20-40 Engine oil	
					Insufficient coolant	Add coolant		Cutting fluid (soluble oil)	
					Insufficient compressed air	Turn on compressor			
		Corrective	1	Technician	Tool changer failure mode	Flip the top ring and use spanner to retract the change arm as you observe one red light In MDI mode enter M66 CODE, turn ring on motor back and lock. Turn compressor on	1/2	Spanner 22	

Appendix XI: Machine History Cards

Machine history card 001

Name of the machine: FURNACE

Location: FOUNDRY SHOP DMPE Commissioned no:

Purchase price: Break down /repair record

S NO.	DATE	BREAK DOWN NO.	PROBLEM	ACTION /PART REPLACED
1	March 2020	001	Blower keeps stopping during melting stage.	weak model of blower for purpose. HK-BL 2302 Replaced carbon brushes less than 6mm width
			Melting of nozzle	Use half meter hollow pipe.
				Recommend for single phase 2hp industrial air blower.

Machine history card 002

Name of the machine: CNC MILLING MACHINE

Location: MACHINE SHOP DMPE

Commissioned no:

Purchase price:

Break down /repair record

S NO.	**DATE**	**BREAK DOWN NO.**	**PROBLEM**	**ACTION /PART REPLACED**
1	March 2020	001	Failure for the tool exchange arm failing to pick tool.	Switch on compressor, lift ring on servo motor turn arm till red light is reflected lock and start.
		002	Alarm on	Revisit program rectify fault and start.
2.	November 2021	003	Alarm on Tool exchanger arm failed	switch on compressor lift ring on servo motor turn arm with spanner till one red light is viewed in MDI mode enter M66 code and start

Appendix XII: Research tools used in the study

KYAMBOGO UNIVERSITY

ENHANCING STUDENTS' COMPETENCE DEVELOPMENT IN FOUNDRY PRACTICE AT DMPE

OBSERVATION CHECKLIST

Institution ….. KYAMBOGO UNIVERSITY

The class observed: BEMME YEAR 3 FOUNDRY TECHNOLOGY TIEM 3105
Date…………………………………………..

Time …………………………………………………….
Observer……………………………………………………..

No.	**Items**	**Observations**		**Comments**
1.	Class Structure	- Number of students.		
		- Number of Males.		
		- Number of Females.		
		- Workshop arrangement.		
		- Workshop location		
2.	**Timetable.**	-Indicate Time of Practical		
			Practical	
3.	**Method**	Technicians Section /Department		
		Technician	- Avails tools	
			- Number of Group members	
			- Assigns task(s)	
			- Supervises	
			- Allows students to reflect.	

			- Listens to responses	
			- Gives feedback	
4.	**Teacher/Technician** – Student Social interaction.	Technician	-Active. -Passive -Catering for learners' needs.	
		Students	-Active -Passive	
5	**Housekeeping in workshops**		-Adequate	
			-Inadequate	
6	**Tools**	.	-Adequate -Inadequate	
7	**Equipment functionality (specify)**		-Good condition	
			-Need maintenance	
			-Need replacement	
8	**Health & Safety precautions**	-	-Students have PPE -Know good foundry practices	

Appendix XIII: Focus Group Discussion Guide

1. What attributes did you consider during pattern making process as a group?
2. During the hands-on training, what learning outcomes /benefits did you acquire from the following;

    i. Rescheduling foundry practical sessions after break time before lunch time?

    ii. Preparing maintenance plan?

    iii. Working from both the Department of Civil workshop and the department of Mechanical workshop?

    iv. Carrying out foundry practical work in groups?

    v. Working on components brought in the DMPE workshop by clients?

3. What should students do to increase their participation in foundry practical work?
4. What should the administration do to improve students' participation in foundry practice?
5. What should the technicians do to improve students' participation in foundry practice?

END

Appendix XIV: Action Research Evaluation Tool of Enhancing Students' Competence Development in Foundry Practice At DMPE.

QUESTIONNAIRE

Respondents; Tick

TITLE: Teaching staff ☐ Student ☐

GENDER: Female ☐ Male ☐

HIGHEST LEVEL OF EDUCATION: Certificate ☐ A-LEVEL ☐ Diploma

Higher Diploma ☐ Bachelor Masters ☐ PHD ☐

The Action research aimed at the following;

a) Examining the gaps hindering students' competence development in foundry practice at DMPE

b) Identifying interventions aimed at enhancing students' competence development in foundry practice at DMPE.

c) Implementing the identified interventions aimed at enhancing students' competence development in foundry practice at DMPE

d) Evaluating the impact of the implemented interventions aimed at enhancing students' competence development in foundry practice at DMPE.

Implementable strategies included;

i) Rescheduling practical sessions after break time to increase the practical time.

ii) Space and foundry equipment availability by; networking with technicians from DCBE and DMPE and preparation of maintenance plan iii) Use of Group learning for more hands-on activities

iv) Access to DMPE workshops to allow students to engage in real-life activities brought by the communities

I am contacting you because you participated in foundry practical work and your name appears on the lists of those that got involved in the implementation of the action research. In light to that I have a few questions to ask you. Please fill in the questionnaire below;

NOTE; you may fill in this questionnaire and send back to me on namuebidinah2006@gmail.com or hand copy not later than 10th November 2020. Please call 0783002633

Information to evaluate the implemented strategies SECTION A: Please tick and/or fill in where appropriate

The following statements are meant to check the impact of the implemented interventions that you participated in. Tick the answer based on scale given for ranking;

1Do not agree 2. Somewhat disagree 3. Do not know 4. Somewhat agree 5. agree to large extent.

1. The intervention set to enhance students' competence development benefited us to a great extent.

a) Rescheduling practical sessions after break time to increase practical time

1. Do not agree at all ☐
2. Somewhat disagree ☐
3. Neutral ☐
4. Somewhat agree ☐
5. Agree to large extent ☐

b) Space and foundry equipment availability by; networking with technicians from DCBE and DMPE and preparation of maintenance plan

1. Do not agree at all ☐
2. Somewhat disagree ☐
3. Neutral ☐
4. Somewhat agree ☐
5. Agree to large extent ☐

c) Use of Group learning for more hands-on activities

1. Do not agree at all ☐
2. Somewhat disagree ☐
3. Neutral ☐
4. Somewhat agree ☐
5. Agree to large extent ☐

d) Access to DMPE workshops to allow students to engage in real life activities brought by the communities

1. Do not agree at all ☐
2. Somewhat disagree ☐
3. Do not know
4. Somewhat agree ☐
5. Agree to large extent ☐

SECTION B: General comments (please write your thought on the interventions in space below)

a. In your opinion which intervention among those that were implemented would you use to increase students' participation in hands-on training and why?

…………………………………………………………………………………………….

…………………………………………………………………………………………
…………………………………………………………………………………………
……

b. **Recommendation for future Action. In your opinion**, what do you think can be done to improve foundry practical lessons?

…………………………………………………………………………………………
……………………………………………………………………………………

c. Which other interventions apart from those listed above could we use to enhance students' competence development in foundry practice?

…………………………………………………………………………………………

d. any additional comments

…………………………………………………………………………………………

Thank you very much for your time

KYAMBOGO UNIVERSITY

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

BACHELOR OF MECHANICAL AND PRODUCTION YEAR 3 SEMESTER I

2021

Time: 6 HRS DATE: 20TH NOVEMBER 2021

QUESTION: PATTERN-MAKING EXERCISE

In groups of not more than five members,

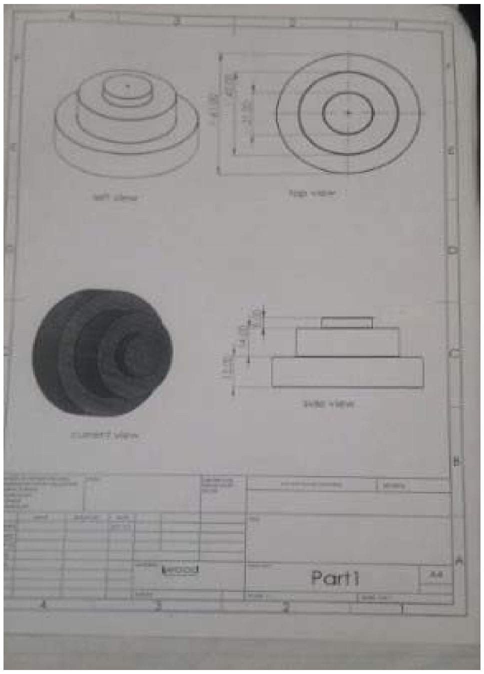
select a metal to be melted for the final casting of your choice and consider any dimension where possible and

i. Develop a draft with at least four attributes of a good pattern ii. Produce a pattern product iii. You are required to present the procedure followed to final pattern iv. Consider the necessary safety aspects during the process.

PATTERN ASSESSMENT TOOL

	Assessment Criteria	**Scoring guide**	**Maximum score**			
			Process		**Results**	
1.	Pattern draft presentation	**Pattern draft Pattern** draft considerations	**5**		**5**	
		Pattern draft copy			**5**	
2.	Presentation of the pattern-making process	**Pattern making process**				
		Observed safety			**5**	
		Tool identification			**5**	
		Procedure for pattern making	**5**		**10**	
		Organized work area			**5**	
3.	Pattern product presentation	**Considered attributes**; Dimension accuracy	**5**		**5**	
		Smooth surface finish	**5**		**5**	
		Rounded corners	**5**		**5**	
		No sudden change in dimension	**5**		**5**	
		Pattern allowances	**5**		**5**	
		Pattern product			**5**	
	Total marks		**35**		**65**	

Appendix XIII: Assessed pattern draft



Pattern drafts were developed before making the patterns.

Appendix XIV: Patterns made by students

Well-prepared   Poorly made the pattern

Appendix XV: Students making the presentation of patterns