Resources for Vocational and Entrepreneurial Skills Development in Powder Metallurgy (PM) Technology

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ABSTRACT

In the current difficult economic situation across the globe, it is only conscious effort geared towards practical entrepreneurial skill development in academic institutions that will guarantee wealth creation and poverty alleviation. Hence, the purpose of this study was to identify appropriate resources for vocational training and entrepreneurial skills development in powder metallurgy technology. To achieve the stated objectives, descriptive survey design was adopted. A population of 114 entrepreneurs was used for the study. They are drawn from fifty-six private powder metallurgy and powder production/processing industries in the categories of managers and supervisors. There was no sampling because the entire population for the study was used since is of manageable size. Seven specific purposes and seven research questions guided the study. The only instrument for data collection was the: Resources for Vocational and Entrepreneurial Skills Development Questionnaire (RVESDQ). The RVESDQ was subjected to face validation by three experts. Cronbach Alpha Coefficient method was used to establish the reliability coefficient index for the instructional resources in clusters according to the components of powder metallurgy technology as follows: theoretical concepts (0.85), powder manufacturing techniques and principles (0.89), powder particle processing (0.77), powder compaction (0.87), heat treatment (0.79), secondary finishing operations (0.86), powder and powder compact characterization (0.89), and the entire instrument (0.85). The seven stated research questions were analyzed using mean, and standard deviation. The findings from the study indicated that 108 items identified as resources for the delivery of powder metallurgy technology in higher vocational technical institutions for entrepreneurship development were all appropriate. Therefore, the study recommends that for effective teaching and learning of powder metallurgy technology in tertiary vocational technical institutions, the identified resources must be provided for lecturers and students; for research and practical teaching purposes. With this, the problem of recessed economy will be partly resolved via application of institutional based approach in provision of vocational training tailed towards entrepreneurship skills development in powder metallurgy technology.

Keywords: Resources, Vocational, Entrepreneurial Skills and Powder Metallurgy (PM) Technology.

INTRODUCTION

Powder metallurgy technology is a virgin area of study in the field of mechanical technology in Nigerian higher vocational technical institutions. But this technology has gained a world wide spread application round the globe for the manufacture of usable metallic and non-metallic products. The principles and techniques of this green technology emanated from the early education but in a crude form; and later appeared successful with the use of suited practical skills development resources (Günster, Engler and Heinrich, 2003). Powder metallurgy technology is a course or subject taught in tertiary institutions and training centers. This technology is all about conversion of bulk materials in their raw form (solid or liquid) into powder particles and further processed into powder metallurgy products. The teaching of this course requires appropriate and specialized instructional resources to aid the lecturers in teaching the

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practical skills in powder metallurgy technology to students of mechanical technology education in higher vocational technical institutions of learning.

In this context, resources for vocational and entrepreneurial skills development in powder metallurgy technology is refer to physical teaching and learning materials/equipment required by the lecturers and students during learning processes. It is for the enhancement of the processes of transfer of theoretical and practical contents of powder metallurgy technology. According to Lanigan (1999) the appropriateness of these resources deployed during teaching and learning processes, makes transfer of skill acquisition effective and interactive. In the view of Ogundu (2013) instructional materials in vocational and technical education are practical and skill developing resources that would facilitate the process of: teaching, learning and evaluation of vocational and technical skills. In this light, resources for powder metallurgy technology could also be described as devices that are developed or acquired to assist vocational technical teachers in transmitting organized knowledge, skills and attitudes to learners. It could be applied in directing, controlling, and reinforcing teaching and learning of purported skills (Lanigan, 2012). Specifically, Kaiser, and Kremer (2003) maintained that some of these instructional resources when used for the delivery of powder metallurgy technology in vocational institutions are capable of training manpower that can produce powder metallurgy products. The development of skills required by students of mechanical technology depends on the relevance and quality of instructional facilities used during classroom instruction. According to Lanigan (2012) equipment, tools, consumable materials and workshops/laboratories are the assorted inputs needed for instructions in vocational technical schools. Also, Chapman (2005) listed some instructional materials as: written or printed materials as: textbooks, manuals, and lecture notes. Others are: audio/visual materials, projected materials (slides, film, video, and transparencies), non-projected materials (drawings, models, and objects), information technology, distant learning and internet/world wide web.

In the view of Maaji (2003) instructional resources used for higher vocational technical school training must be comparable to those used in the industries. This is to enable them acquire skills that is relevant to the labor market. When learners are taught without these facilities, they find it difficult to practice after graduation. Mohamed (2008) noted that lack of equipment in any instructional program, will disconnect the student learners (trainees) from the practical content of the study which denies them the needed knowledge and manipulative skills required of them in that field of study. Hence, Rob (2010) and Clark (2007) identified instructional materials as materials that generates the interest of the learners, supports teaching and facilitate communication. Housel (2002) stated that the role of instructional materials is to provide guidance to the teacher and learner. Ball (1996) and Chapman (2005) reported that a good instructional material must be: presented for a specific purpose; well-defined audience (educational level, experience, and knowledge); they should have clear teaching and learning objectives, be technically correct, enhanced through instructional components, logically and systematically presented, attractive, evaluated and tested.

In the same vein, Noe (2008) opined that a good printed instructional resource must possess the following instructional components: introduction, curriculum planning, instructional planning, resources, teaching, learner application, and learner evaluation. At the end of the administration of the material, Housel (2002) suggested six basic questions to be considered by the teacher as self - evaluation test questions to ascertain the quality of the training material he has used for the teaching and learning process. They are: why evaluate, who evaluates, what to evaluate, what content and format to evaluate, and how to evaluate. Hamza (2012) reported that content of teaching resources should be evaluated based on: target audience, reading level, correctness of content (current, and accuracy), instructional components, essential information and elaborations, well-organized, logical, well-illustrated, and without propaganda or

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bias. On evaluation format, Lanigan (1999) recommended that it should take the following order: equipment and infrastructure requirements, quality practical, ease of use (instructional components), and the overall attractiveness of the material. For easy reference and identification, there is need to classify the instructional resources according to individual vocational and entrepreneurial skill components of powder metallurgy technology. Uematsu, Uchida, and Tanaka (2006) classified seven key need areas for entrepreneurial skill development in powder metallurgy technology as: theoretical content, powder manufacturing, powder particles processing, powder compaction (pressing), heat treatment (sintering), powder and powder compacts characterization, and secondary finishing operations. But, the teaching and learning of the components of this technology is witnessing some difficulties in terms of appropriate resources identification and utilization.

Statement of the Problem

Powder metallurgy technology is a practical oriented course and is studied by mechanical technology education students' of higher vocational technical education schools (University, Polytechnic and the Colleges of Education). This course as a specialized area in the field of manufacturing practices requires standardized identifiable list of instructional resources known to both students' and lecturers for effective knowledge and skills delivery.

But regrettably, the teaching and learning of this green technology in Nigerian higher vocational technical education institutions is suffering some difficulties as a result of lack of clear mark of identification and usage of appropriate instructional resources for vocational training and entrepreneurial skill development.

Again, students graduate from these institutions with degree in manufacturing technology without been able to identify and use required resources for powder metallurgy technology application for private business ventures. This problem also affects the lecturers of this course, as they find it difficult to deliver the needed practical skills for enhancement of entrepreneurship skill development of students after school. This is as a result of lack of knowledge on appropriate resources for knowledge and skill transfer.

Hence, the early research effort channeled towards identification of appropriate resources for vocational training and entrepreneurial skill development in powder metallurgy technology amongst mechanical technology education lecturers and students, the better they will be equipped to setup entrepreneurial ventures to tackle economic related problems through application of powder metallurgy processes in the manufacture of useable products and reduction of unemployment and poverty.

Purpose of the Study

The purpose of this study is to identify appropriate resources for vocational and entrepreneurial skills development in powder metallurgy technology. Specifically, the study sought to identify resources for teaching practical entrepreneurial skills content in the following areas of PM technology:

1. Theoretical content
2. Powder manufacturing techniques and principles
3. Powder processing
4. Powder compaction (Pressing)
5. Heat treatment (Sintering)
6. Secondary finishing operations and
7. Powder and powder compacts characterization.

Research Question

The following Research Questions (RQ) guided the study;

1. What are the appropriate resources for vocational and entrepreneurial skill development in theoretical content of PM technology?
2. What are the appropriate resources for vocational and entrepreneurial skill development in powder manufacturing techniques and principles?

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3. What are the appropriate resources for vocational and entrepreneurial skill development in powder processing?
4. What are the appropriate resources for vocational and entrepreneurial skill development in powder compaction (Pressing)?
5. What are the appropriate resources for vocational and entrepreneurial skill development in heat treatment (sintering) processes?
6. What are the appropriate resources for vocational and entrepreneurial skill development in secondary finishing operations?
7. What are the appropriate resources for vocational and entrepreneurial skill development in powder and powder compact characterization?

RESEARCH METHODOLOGY

This study adopted descriptive survey design. The research was conducted in South-South and South-East geopolitical zone of the Federal Republic of Nigeria. The population for this study was 114 Entrepreneurs in fifty-six identified private powder metallurgy and powder production/processing industries. There was no sampling because the entire population was studied since they are of manageable size.

The "Resources for Vocational and Entrepreneurial Skills Development Questionnaire (RVESDQ)" was the only data collection instrument used for this study. The instrument was a five point rating scale with response coding options: Most Appropriate (MA); Appropriate (A); Undecided (U); Not Appropriate (NA); Strongly Not Appropriate (SNA) with numerical values: 5, 4, 3, 2 and 1 assigned to the respective respond categories. The RVESDQ was face validated by three experts (powder metallurgy practitioner, measurement and evaluation expert, and a mechanical technology Educationist). Comments and suggestions from these experts were accepted and finally included into the final design of the instrument. The reliability index of the instrument for the resources are in clusters with respect to the components of powder metallurgy technology; and was established using Cronbach Alpha Coefficient in the following order: theoretical concepts (0.85), powder manufacturing techniques and principles (0.89), powder particles processing (0.77), powder particles compaction (0.87), heat treatment (0.79), secondary finishing operations (0.86), powder and powder compact characterization (0.89); and the entire instrument (0.85). Thirty copies of the instrument was trial tested at University of Nigeria, Nsukka, Enugu state in South-East region of Nigeria outside the study area. The instrument for data collection was personally administered to the respondents. Out of the 114 copies of the questionnaire administered, only 111 copies were withdrawn representing 97% return rate and were used for data analyses for this study.

The statistical instrument used for analyzing the research questions was the mean and standard deviation. The decision rule holds that any mean rating with 3.50 and above was regarded as appropriate resources for vocational and entrepreneurial skill development in powder metallurgy technology; while mean rating below 3.50 was regarded as not-appropriate resources.

RESULTS

The data presented in Tables 1 – 7 below are the results for the stated research questions that guided the study.

Research Question 1: What are the appropriate resources for vocational and entrepreneurial skill development in theoretical content of PM technology?

The results answering RQ_1 above are contained in Table 1. It shows the mean and standard deviation of respondents on appropriate resources for vocational and entrepreneurial skill development in theoretical content of PM technology.

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Table 1: Mean and Standard Deviation Responses of PM Entrepreneurs on resources for Theoretical content of powder metallurgy technology

Item	Instructional Resources	Mean	SD	Decision
1.	Printed materials	4.72	0.45	*
2.	Projected materials	4.61	0.66	*
3.	Non-projected materials	4.40	0.77	*
4.	Computers	4.36	0.93	*
5.	Classrooms	4.31	0.98	*
6.	Library	4.34	0.88	*
7.	Projectors and accessories	4.65	0.63	*
	Grand Mean and SD	**4.48**	**0.76**	

= Appropriate, PM = Powder metallurgy

Table 1 above showed a grand mean and standard deviation score ($\overline{X}$ = 4.48, SD = 0.76) for resources for vocational and entrepreneurial skill development in theoretical content of powder metallurgy technology. Among the resources, printed materials (textbooks, manuals and lecture notes) ($\overline{X}$ = 4.72, SD = 0.45) were rated as key resources for vocational and entrepreneurial skill development in theoretical concepts of powder metallurgy technology. This was followed by projected instructional aides (slides, film, videos and transparences) ($\overline{X}$ = 4.61, SD = 0.66). The classrooms ranked the least among the instructional facilities ($\overline{X}$ = 4.31, SD = 0.98). The finding indicated that the resources for vocational and entrepreneurial skill development in theoretical content of powder metallurgy technology were all appropriate and best suited for use in higher vocational technical education institutions.

Research Question 2: What are the appropriate resources for vocational and entrepreneurial skill development in powder manufacturing techniques and principles?

The results answering RQ_2 above are contained in Table 2. It shows the mean and standard deviation of respondents on appropriate resources for vocational and entrepreneurial skill development in powder manufacturing techniques and principles.

Table 2: Mean and Standard Deviation Responses of PM Entrepreneurs on resources for Practical skill in powder manufacturing techniques and principles

Item	Instructional resources	Mean	SD	Decision
1.	Workshops	4.66	0.56	*
2.	Powder production/processing laboratory	4.64	0.56	*
3.	Leather aprons	4.52	0.60	*
4.	Google glasses	4.59	0.56	*
5.	Nose mask	4.38	0.67	*
6.	Lab coats	4.36	0.80	*
7.	Roll crusher	4.14	1.04	*
8.	Cone crusher	4.07	1.23	*
9.	Jaw crusher	4.27	0.98	*
10.	Lab superfine impact mill	4.18	1.09	*
11.	LHN pin mill	4.46	0.93	*
12.	Lab cyclonic jet mill	4.67	0.59	*
	Grand Mean and SD	***4.41***	***0.80***	

= Appropriate, PM = Powder metallurgy

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Table 2 indicated a grand mean and standard deviation score ($\overline{X}$ = 4.41, SD = 0.80) for instructional resources for vocational and entrepreneurial skill development in powder manufacturing techniques and principles. The finding showed that the respondents strongly indicated that lab cyclonic jet mill ($\bar{X}$ = 4.67, SD = 0.59) was a key resources for vocational and entrepreneurial skill development in powder manufacturing methods and principles. This was followed by workshops ($\overline{X}$ = 4.66, SD = 0.56), and the least was cone crusher having ($\overline{X}$ = 4.07, SD = 1.23). The overall results showed that the resources for vocational and entrepreneurial skill development in powder manufacturing methods and principles for mechanical technology students' were appropriate for use in Nigerian higher vocational and technical education institutions.

Research Question 3: What are the appropriate instructional resources for vocational and entrepreneurial skill advancement in powder processing?

The results answering RQ_2 above are contained in Table 3. It showed the mean and standard deviation of respondents on appropriate instructional resources for vocational and entrepreneurial skill advancement in powder particle processing.

Table 3: Mean and Standard Deviation Responses of PM Entrepreneurs on resources for practical skill in powder particle processing

Item	Instructional resources /Students' Ratio	Mean	SD	Decision
1.	Raw powders of: aluminum, zinc, iron	4.55	0.63	*
2.	Deflocculant (Na_2CO_3,Na_2SiO_3)	4.48	0.74	*
3.	Plasticizers (tributyl phosphate, camphor & triacetin)	**4.74**	**0.66**	*
4.	Wetting agents (spirited substance)	4.73	0.52	*
5.	Accelerators(additives)	**4.78**	**0.53**	*
6.	Air entrainment agents (additives)	4.56	0.66	*
7.	Retarders (additives)	4.58	0.63	*
8.	Workability agents (additives)	4.56	0.65	*
9.	Binders - molasses, starch, bentonite	4.57	0.69	*
10.	Lubricants - vegetable oils, soap	4.65	0.67	*
Powder Particle Blending and Mixing				
11.	Powder compaction (pressing) lab.	4.50	0.76	*
12.	Hot/ cold rooms	4.32	0.85	*
13.	Heat treatment (sintering) lab.	4.49	0.96	*
14.	Lab air classifier LHB	4.21	1.09	*
15.	Mini rotary batch mixers	4.20	1.28	*
16.	Rotary continuous mixer	4.47	0.90	*
17.	Rotary batch dryer	4.57	0.86	*
18.	Blenders	4.51	0.86	*
19.	Self-diffluent classifier	4.41	1.07	*
20.	LHQ classifying micronizer	4.42	1.03	*
21.	Powder filling machine	4.47	0.86	*
22.	Denver-froth-flotation machine	4.64	0.62	*
23.	Rod mill	4.51	0.66	*
24.	BICO pulverizing machine	4.54	0.82	*
25.	Wilfley shaking table	4.49	0.85	*
26.	Powder disaggregator mill	4.43	0.87	*
27.	Rotary permanent separator	4.49	0.85	*
28.	Powder mixing machine	4.56	0.72	*
	Grand Mean and SD	***4.678***	***0.80***	

****= Appropriate, PM = Powder metallurgy***

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Table 3 indicated a grand mean and standard deviation score ($\bar{X}$ = 4.68, SD = 0.80) for resources for vocational and entrepreneurial skill development in powder particle processing. The finding showed that the respondents strongly indicated that accelerators (additives) ($\bar{X}$ = 4.78, SD = 0.53) was ranked top instructional resources for vocational and entrepreneurial skill development in powder particles processing. This was followed by plasticizers (tributyl phosphate, camphor, triacetin and others with ($\bar{X}$ = 4.74, SD = 0.66), and the least was mini rotary batch mixers ($\bar{X}$ = 4.20, SD = 1.28). The results showed that the resources for vocational and entrepreneurial skill development in powder particle processing were all apt.

Research Question 4: What are the appropriate resources for vocational and entrepreneurial skill development in powder compaction (pressing)?

The results answering RQ_4 above are presented in Table 4 below. It showed the mean and standard deviation responses of respondents on appropriate resources for vocational and entrepreneurial skill development in powder compaction (pressing).

Table 4: Mean and Standard Deviation Responses of PM entrepreneurs on resources for Practical skills in powder compaction

Items	Instructional resources	Mean	SD	Decision
1.	Hot Isostatic Press (HIP)	4.49	0.80	*
2.	Briquetters	4.47	0.73	*
3.	Lab size pellet mill	4.60	0.71	*
4.	Roller compactor	4.61	0.75	*
5.	Sheet bending machine	4.59	0.71	*
6.	Hydraulic shear machine	4.52	0.82	*
7.	Plate rolling machine	4.54	0.82	*
8.	Hydraulic press	4.49	0.83	*
9.	Mini cold isostatic	4.50	0.87	*
10.	Compactor and granulators	4.49	0.84	*
11.	Mini compacting presses	4.57	0.73	*
12.	LAEIS press alpha 1500	**4.64**	**0.85**	*
13.	Ball mill	4.58	0.79	*
14.	Rod mill	4.60	0.80	*
15.	Molds	4.61	0.73	*
16.	Trowel	4.53	0.73	*
	Grand Mean and SD	**4.55**	**0.05**	

= Appropriate, PM = Powder metallurgy

Table 4 showed a grand mean and standard deviation score of ($\bar{X}$ = 4.55, SD = 0.05) for instructional resources for vocational and entrepreneurial skill development in powder compaction (pressing). LAEIS press alpha 1500 ($\bar{X}$ = 4.64, SD = 0.85) was indicated as a major resource for vocational and entrepreneurial skill development in powder compaction. This was followed by roller compactor ($\bar{X}$ = 4.61, SD = 0.75) and molds ($\bar{X}$ = 4.61, SD = 0.73). The least instructional resources was hot isostatic press ($\bar{X}$ = 4.49, SD = 0.80). However, the finding showed that the suggested resources for vocational and entrepreneurial skill development in powder compaction were all appropriate for use in tertiary vocational technical institutions.

Research Question 5: What are the appropriate resources for vocational and entrepreneurial skill development in heat treatment processes?

The results answering RQ_5 above are presented in Table 5. It showed the mean and standard deviation of respondents on appropriate resources for vocational and entrepreneurial skill development in heat treatment (sintering) processes.

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Table 5: Mean and Standard Deviation of Responses of PM Entrepreneurs on Resources for practical skills in heat treatment processes

Items	Instructional resources	Mean	SD	Decision
1.	Hot Quasi-isostatic pressing simulator	4.51	0.74	*
2.	Crucible type baleout furnace	4.39	0.77	*
3.	Rotary furnace	4.40	0.78	*
4.	Heating plant	4.27	1.02	*
5.	Lab muffle furnace	4.36	0.98	*
6.	Box type furnace	**4.19**	**1.00**	*
7.	Annealing normalizing furnace	4.39	0.92	*
8.	Heat resistance gloves	4.35	1.01	*
9.	Tongs	**4.19**	**1.23**	*
	Grand Mean and SD	**4.34**	**1.08**	

= Appropriate, PM = Powder metallurgy

Table 5 showed a grand mean and standard deviation score ($\bar{X}$ = 4.34, SD = 1.08) for resources for vocational and entrepreneurial skill development in heat treatment (sintering) processes. Hot Quasi-isostatic pressing simulator with ($\bar{X}$ = 4.51, SD = 0.74) was strongly indicated as a major resources for vocational and entrepreneurial skill development in sintering processes. This was followed by rotary furnace ($\bar{X}$ = 4.40, SD = 0.78). The least resources was box type furnace ($\bar{X}$ = 4.19, SD = 1.00), and tong ($\bar{X}$ = 4.19, SD = 1.23). This finding indicated that the resources were appropriate for vocational and entrepreneurial skill development in sintering processes and well suited for use in higher vocational technical education institutions.

Research Question 6: What are the appropriate resources for vocational and entrepreneurial skill development in secondary finishing operations?

The results answering RQ_6 above are contained in Table 6. It showed the mean and standard deviation of respondents on appropriate resources for teaching practical skill in secondary finishing operations.

Table 6: Mean and Standard Deviation of Responses of PM Professionals on resources for Practical skill in secondary finishing operations

Item	Resources	Mean	SD	Decision
1.	Sand papers	4.43	1.05	*
2.	Carburizing equipment	4.61	0.67	*
3.	Leath	4.63	0.61	*
4.	Files (assorted)	4.50	0.78	*
5.	Hand drill	4.48	0.87	*
6.	Portable drilling machine	4.68	0.56	*
7.	Wire brush	4.60	0.63	*
8.	Punch	4.53	0.78	*
9.	Anvil and stand	4.35	0.85	*
10.	Double column band-saw	4.24	1.03	*
11.	Rubber mallet	4.27	0.96	*
12.	Bench vices	4.19	1.24	*
13.	Work bench	4.51	0.81	*
14.	Solder	4.43	0.98	*
15.	Set of chisels	4.30	1.02	*
16.	Pliers (assorted)	4.55	0.70	*
17.	Blanking machine	4.57	0.81	*
	Grand Mean and SD	**4.46**	**0.84**	

= Appropriate, PM = Powder metallurgy

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Table 6 showed a grand mean and standard deviation score ($\overline{X}$ = 4.46, SD = 0.84) for resources for vocational and entrepreneurial skills development in secondary finishing operations. The respondents strongly indicated that portable drilling machine ($\overline{X}$ = 4.68, SD = 0.56) was a key equipment for vocational and entrepreneurial skill development in secondary finishing operations. This was followed by leath ($\overline{X}$ = 4.63, SD = 0.61) and the least was bench vices ($\overline{X}$ = 4.19, SD = 1.24). The finding showed that the suggested resources for teaching practical skill in secondary finishing operations were appropriate and well suited for use in higher vocational technical institutions.

Research Question 7: What are the appropriate resources for vocational and entrepreneurial skill development in powder and powder compact characterization?

The results answering RQ_7 above are presented in Table 7 below. It shows the mean and standard deviation of respondents on appropriate resources for vocational and entrepreneurial skill advancement in powder and powder compact characterization.

Table 7: Mean and Standard Deviation Responses of PM Entrepreneurs on resources for Practical skills in powder and powder compact characterization

Item	Instructional resources	Mean	SD	Decision
1.	Powder screening machines	4.77	0.57	*
2.	Wall friction tester	4.63	0.61	*
3.	Vertical shear tester	4.62	0.77	*
4.	Tensile tester	**4.82**	**0.47**	*
5.	Annular shear and attrition tester	4.69	0.58	*
6.	Cohesion tester	4.61	0.62	*
7.	Powder flow tester	4.57	0.65	*
8.	Micro powder characterizer	4.49	0.70	*
9.	Transmission light microscope	4.51	0.82	*
10.	LEITZ reflected light microscope	4.53	0.80	*
11.	LEICA microscope spectrometer	4.20	1.02	*
12.	Gieseler plastometer	4.37	0.99	*
13.	Test shaker with set of sieves	4.43	0.76	*
14.	Analytical weighing balance	4.38	0.92	*
15.	Vernier caliper	4.53	0.84	*
16.	Try square	4.39	1.12	*
17.	Micrometer screw gauge	4.25	1.24	*
18.	Measuring rule	4.66	0.58	*
19.	Compressive strength tester	4.55	0.70	*
	Grand Mean and SD	**4.53**	**0.78**	

= Appropriate, PM = Powder metallurgy

Table 7 showed a grand mean and standard deviation score ($\overline{X}$ = 4.53, SD = 0.78) for equipment and tools for vocational and entrepreneurial skill development in powder and powder compacts characterization. From the finding, it was noticed that tensile tester ($\overline{X}$ = 4.82, SD = 0.47) was strongly rated as a key resources for vocational and entrepreneurial skill development in powder and powder compact characterization. This was followed by powder screening machines ($\overline{X}$ = 4.77, SD = 0.57) and the least among them was micrometer screw gauge ($\overline{X}$ = 4.25, SD = 1.24). This result revealed that the resources suggested for teaching practical skill in powder and powder compact characterization were very appropriate and good for use in higher vocational technical education institutions.

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FINDINGS OF THE STUDY

The study finds 108 appropriate resources for vocational and entrepreneurial skill development in powder metallurgy technology to be used in higher vocational technical education institutions. The resources were identified in clusters according to the components of powder metallurgy technology, and their corresponding grand means and standard deviation scores are: resources for delivery of theoretical content recorded ($\overline{X}$ = 4.48, SD = 0.76); powder manufacturing techniques and principles ($\overline{X}$ = 4.41, SD = 0.80); powder particles processing ($\overline{X}$ = 4.68, SD = 0.80); powder compaction ($\overline{X}$ = 4.55, SD = 0.05); heat treatment processes ($\overline{X}$ = 4.34, SD = 1.08); secondary finishing operations ($\overline{X}$ = 4.46, SD = 0.84); and finally, powder and powder compact characterization ($\overline{X}$ = 4.53, SD = 0.78).

DISCUSSION OF FINDINGS

Table 1 contained analyzed data for RQ_1. It showed resources for vocational and entrepreneurial skill development in theoretical content of powder metallurgy technology. The findings agreed with the view of Ogundu, (2013) that instructional resources or materials are practical and skill developing resources that is capable of facilitating the process of teaching, learning and evaluation processes of vocational and technical skills. Also the perception of Lanigan (2012) is in line with the description of instructional resources that they are devices used in directing, controlling, and reinforcing teaching and learning of purported skills. Lanigan (2012) went further to classify these resources as equipment, tools, consumable materials, workshops and laboratories. Chapman (2005) in addition identified and listed some of the instructional aides as: written or printed materials like textbooks, manuals, and lecture notes. Kaiser and Kremer (2003) added that some of these equipment and facilities could be used to produce other materials.

Table 2 described analyzed data for RQ_2. It indicated instructional resources for vocational and entrepreneurial skill development in powder manufacturing techniques and principles. The findings conformed to the assertions of Uematsu, Uchida, and Tanaka (2006) on classification of powder production and processing equipment. According to them, teaching aides for manufacture of powder particles are resources used in powder metallurgy laboratories and workshops for teaching the processes of conversion of bulk materials into powder particles such as: leather aprons, goggle glasses, nose mask, lab coats, roll crusher, cone crusher, jaw crusher, lab superfine impact mill, lab cyclonic jet mill and others.

The result in Table 3 is for RQ_3. It revealed the mean ratings of the respondents on instructional resources for vocational and entrepreneurial skill advancement in powder particles processing. The findings agreed with the position of Uematsu, Uchida, and Tanaka (2006), and Kaiser, and Lutz (2011) that listed: millers, mixers, dryers, blenders, separators, powder dis-aggregator mill, rotary permanent magnetic separator, self-diffluent classifier, LHQ classifying micronizer, LHN pin mill, mini rotary batch mixers, rotary batch dryers/coolers/moisturizers and magnetic stirrer as powder processing instructional resources.

The results found on Table 4 are for RQ_4. It agreed with the position of Avure Autoclave Systems (2014), that listed instructional equipment for powder compaction (pressing) process as those resources needed in teaching and learning processes of pressing the powder particles in to shapes (green bodies). Avure Autoclave Systems, (2014) enumerated these instructional aides as: cold and hot isostatic press, briquetters, pellet mill, roller compactor, rotary / multi-station tableting press, and single station press.

The position of Avure Autoclave Systems Inc. (2014) is congruent with the analyzed data on Table 5. Autoclave Systems Inc. (2014) named some of the sintering furnaces used in powder metallurgy technology as: crucible type bale out, rotary, annealing normalizing, box type, laboratory muffle, and heating plant furnaces.

Tables 6 and 7 indicated data analyzed for RQ_6 (secondary finishing operations); and RQ_7 (characterization of powder and powder compact). The findings of Table 6 agreed with the definition of instructional resources for vocational and

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entrepreneurial skill advancement in optional secondary finishing operations given by Kaiser and Lutz (2011), that instructional aides for secondary finishing operations are those teaching aids that help in final shaping of powder metallurgy compact before or after sintering operation. Kaiser and Lutz (2011), mentioned these resources as: sand papers, carburizing equipment, leath, files (assorted), hand drill, portable drilling machine, wire brush, punch, anvil and stand, double column band-saw machine and others. Also in the opinion of Kaiser and Lutz (2011), instructional resources for characterization of powder or powder compact, are those resources (machines and tools) used for investigating the: physical, chemical, and mechanical properties of produced powder particles or powder compact. Such resources include: powder particle screening machine, wall friction tester, vertical shear tester, tensile tester, powder flow tester, cohesion tester and others.

The observed mean ratings from Tables 1 – 7 agreed that the 108 identified items as resources for vocational and entrepreneurial skill development in powder metallurgy technology in higher vocational technical education institutions are all appropriate; because they fell above the cut-off bench mark for acceptance.

CONCLUSION

On the whole, the study found one hundred and eight appropriate and well suited resources for vocational and entrepreneurial skill development in powder metallurgy technology for use in higher vocational technical education institutions. In conclusion, lack of these resources in the teaching and learning of powder metallurgy technology in tertiary vocational education schools, will disconnect and deny mechanical technology education students from theoretical and manipulative content of powder metallurgy technology required for vocational and entrepreneurial skill development in private business ventures aimed at creating employment for economic growth and poverty reduction.

RECOMMENDATIONS

It is therefore, recommended that for genuine vocational and entrepreneurial skill development in powder metallurgy technology in higher vocational technical education institutions, the respective government at various levels (Federal, state and local) should provide the identified resources to the relevant schools to enable lecturers and students of mechanical technology; (option: manufacturing practices) train with them to enable them carry out pre-requisite practical components of PM that will lead them into manufacture of powder metallurgy mechanical parts and other related powder technology based products.

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