ENHANCING LEARNING THROUGH A HEALTHY AND SAFE ENVIRONMENT IN THE DESIGN AND TECHNOLOGY WORKSHOP.

BY

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DECLARATION

I declare that the dissertation for the degree of Master of Education (Technology Education) at the North-West University (Mafikeng Campus) has not previously been submitted by me for a degree at this or other university. This is my own work in design and execution and that all materials taken from other sources contained herein have been duly acknowledged.

Victor Ng'ambi

Signature:............................

Date: November 2008

ACCEPTANCE FOR EXAMINATION

This dissertation: **Enhancing learning through a healthy and safe environment in the design and technology workshop**, by Victor Ng'ambi, (17130018) in the School of Post Graduate Studies, Faculty of Education is hereby recommended for acceptance for examination.

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ABSTRACT

This study was undertaken to determine what measures could be taken to promote a healthy and safe learning environment in the design and technology workshop, through the design of a dust extraction system. The sample was taken from all design and technology classes at the International school of South Africa (ISSA) in Mafikeng. Three Form 2 classes in the school participated in the study. A total of sixty learners were involved in the study. A case study method was used in this study. Data was gathered from questionnaire, observation and interviews to establish strategies that could effectively enhance the learning environment.

The study analyzed dust extractor which meant incorporating the designs, methods of extractions and cognitive preferences of the workshop environment. When creating a dust extractor for maximum flexibility, systematic attention must be given to particular design guidelines which include specifications.

Results indicated that generally the dust in the workshop affected the performance of learners during learning. However, there were other machine areas in the workshop that needed proper dust removers from the point of source. These included systems of dust extraction and providing a healthy and safe environment.. This indicated that the installation of an ideal dust extraction system would promote a safe and healthy environment in the design and technology workshop, which would enhance learning.

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ABREVIATIONS AND ACRONYMS

ACHIH	American conference of governmental industrial hygienists, Inc
ASHRAE	American society of heating, refrigeration and air conditioning engineers Inc
°C	Degrees celsius
Cfh	Cubic feet per hour
Cfm	Cubic feet per minute
Cfm/ft^2	Cubic feet per minute per square foot
CFR	Code of federal regulations
cm	Centimeter
Cm	Cubic meters per second
D	Depth
FRP	Fiberglass reinforced plastic
H	Height
HEPA	High efficiency particulate air
HVAC	Heating, ventilation, and air conditioning
HVLP	High volume, low pressure
IV	Industrial ventilation
LEL	Lower explosive limit
M	Meter
MEC	Minimum explosive concentration
mm	Millimeter
m/s	Meter per second
NIOSH	National institute of occupational safety and health
Pa	Pascal
PEL	Permissible exposure limit
PPE	Personal protective equipment

CHAPTER 1

ORIENTATION

1.1 Introduction and background

The workshop is where learners gain knowledge and apply manipulative skills in a range of problem solving activities. This is done through generic learning projects, carried out by the learners in applying their learning experiences, purposeful application of knowledge experiences and resources to create products and processes that meet human needs in design and technology (Ritz and Walter, 1992:3). In the process of manufacturing their products, learners use the sander and band saw machines in an attempt to produce aesthetic artefacts. These machines produce large quantities of dust. Fine dust is a serious health hazard especially for learners with respiratory problems. Even if one feels that dust is not a bother, it can have cumulative effects eventually resulting in permanent health damage. When dust settles in the machine parts, it causes rust and negatively affects the performance of the machines in the workshop.

Personal technology environment awareness and use is a major factor in developing a healthy and safe workshop environment. Awareness of safe environment procedure applications requires analysis of the workshop learning processes. It requires analysis of the technology learning processes themselves to determine strategies of improving the working environment in workshop.

According to Garrat (1995:4) people live in a very high technological society; in simple terms this means that people's way of life, their living standards, health, safety and wealth of their countries depend on the manufacture of sophisticated products in the workshops. According to DeVore (1990:19) the design, selection and development of energy efficient and environmentally compatible technical means are essential components of the on going process of creating a place to live and work. And the quality of life in a community is directly related to the quality and appropriateness of the technological base of the community. This means that learners can produce high quality products if they work in a healthy and safe environment. In an attempt to protect themselves, learners wear dust masks/mouth pieces. These are acceptable in emergencies, but they soon get sweaty and uncomfortable. Masks do not give a perfect seal and will not work with beard nor facial contours. Even a good mask will let around 5% of dust through (Child, 2005:2).

The public health practitioners in America have known for decades that contaminants within many buildings were capable of causing and spreading disease. Scientific experiments on ventilation requirements conducted in the 1920s and 1930s led to the estimate of need for 5-30 cubic feet of outside air per person per minute for odour control. These were the basis for adoption of ventilation standards by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE, 1999:2). The learners and educators are at risk of diseases from dust produced when undertaking Design and Technology activities in the workshop. It is, therefore, against this background that the researcher will study the workshop and find ways that could bring about a safe and healthy learning environment in the Design and Technology workshop at the International School of South Africa (ISSA).

1.2 Problem statement

Design and Technology activities present one of the highest levels of risk for injury to staff and students. Therefore, it is essential that the hazards associated with each activity are identified and the risk of injury assessed and minimized. Clinic records at the International School of South Africa (ISSA) medical centre indicated that there are a number of cases of learners' complaints about the dust in the workshop (Sister Atong, Medical Centre Report File 1993-2003). Design and Technology is a core curriculum subject, and purchasing of dust masks constantly could become a financial burden as this drains the resources for purchasing more learning materials. Thus a more economic and sustainable approach needed to be pursued.

Design and technology workshops are fitted with various machines. These machines are used in various manufacturing activities that take place during learning in the workshop. This is done to enhance the learners' efficiency in manufacturing their artefacts. In order to facilitate the continuity of tasks in the Design and Technology workshop, a sanding disk (sander) is attached to the wood lathe. The dust produced during these learning activities is a cause for concern as it affects the learners' concentration and their health is at risk while working. Generally hazard identification and risk management guidelines require to identify, assess and control the risks in Design and Technology which are based primarily on the occupational safety and health act 1984, (OSH) and occupational safety and health regulations 1996.

The duty of care for students, occupational safety and health and risk management at every learning institution is the responsibility of the management of the school. The policies of the International School of

South Africa place responsibility on the head of department to ensure that educators, learners and visitors are not exposed to hazards and that all employees undertake risk management processes in all planning and work related activities in the Design and Technology workshop. The educators are trained to teach technology but do not have enough knowledge and understanding of mechanical and electrical systems, and do not have the necessary prerequisites to plan, execute and develop a system of this nature. The problem of dust produced during the manufacturing processes in the workshop was a hindrance to the learners' performance. The researcher investigated how learning can be enhanced through a healthy and safe environment in the Design and Technology workshop.

1.3 Purpose of the study

The purpose of this study was to investigate measures that could be taken to promote a safe, healthy and conducive learning environment in the Design and Technology workshop at the International School of South Africa. Tied to this purpose were to develop knowledge and understanding of how to design and manufacture a workable dust extraction system for a Design and technology workshop.

1.4 Research questions

The study was guided by the following research questions:

1.4.1 What measures can be taken to promote a healthy and safe learning environment in the Design and Technology workshop?

1.4.2 How can a dust extraction system be designed to solve the problem of dust in the workshop?

1.4.3 What are the views of staff and learners regarding health and safety in the Design and technology workshop?

1.5 Rationale for the study

This study was important because it would begin a systematic study of the benefits that learners and educators might achieve by working in a healthy, safe and motivating environment. Parents of learners might have less health concerns for their children. Cleaners might spend less time on cleaning the workshop floors, window sills and machines because there would be less dust in the workshop. Contractors might use this system as it is transferable to other workshops and industrial settings. The Design and Technology workshop is equipped with machines and tools that emit a considerable amount of dust during manufacturing processes in the workshop. A school workshop is not a classroom; it is a very special environment covered by its own set of laws within the Health and Safety at Work Act (1993). Being safe in a workshop is very much about being aware. An awareness of possible dangers is learnt by being taught about the right way to do things, and why it might be dangerous to do things in a wrong way in a healthy and safe working environment. A lot of health problems are caused by working in unhealthy environments. Having a clean, tidy and a safe workshop may greatly reduce the risks of injury and health creating high performance opportunities for both the learners and the educators.

The study focused on the knowledge of mechanical systems and designs that could operate at different levels to ensure the working environment was safe in the Design and Technology workshop. It sought to identify and ensure that risks were adequately considered in a structured and systematic way, which allowed them to be incorporated into the planning and execution of activities to create a safe environment in the workshop.

1.6 Limitations of the study

The interpretation of the current dust extraction systems was based on the researcher's own knowledge and experience, discussion with the health and maintenance department at the International School of South Africa (ISSA) and interviews with learners and members of staff. The interviews were conducted to broaden the researcher's knowledge about the subject matter and to provide for a practical comprehension of the current dust extraction practices. It is essential to realize that these interviews and questionnaires were not intended to present a general survey for the prevailing dust extraction system practices in Design and Technology workshops. Therefore the outcome of the interviews, observations and questionnaire only reflected the practices and opinions of the interviewees.

The limitations of a case study are that the researcher, in gathering information involved a few individuals and therefore, this was not representative of the general group or population. Also, much of the information collected was retrospective data, recollections of past events and was, therefore, subject to the problem inherent to memory. Findings cannot be generalized due to a small sample (not representative). The allocation of major resources is a main decision considered in Design and Technology. A major resource addressed in this research consisted of the primary equipment, (For example capture hood, ducts, fan, and dust collectors) that affects the selection of major means of dust extraction methods, as well as the workshop layout.

1.7 Definition of terms

System: A group of interacting interrelated or interdependent elements forming a complex whole. A functionally related group of elements such as a group of interacting mechanical or electrical components (Chapman and Peace, 2000:141).

Carcinogen: Any substance that causes cancer. Wood dust is known to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in humans. An association between wood dust exposure and cancer of the nasal cavity has been observed in many case reports, cohort studies and case control studies that specifically addressed nasal cancer (International Agency for Research on Cancer Publication, Tenth Report on Carcinogens, 2002:2).

Hood: A device that encloses, captures, or receives emitted contaminants. Designs of exhaust hoods should enclose all processes to the greatest possible extent without inhibiting operations (Local Exhaust Ventilation Publication, 2005:3).

Local exhaust ventilation: An industrial ventilation system that captures and removes emitted contaminants before dilution into the ambient air of the work place (Local Exhaust Ventilation Publication, 2005:2).

Design and Technology: It is the use of knowledge, skills and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration (Garrat,1995:5).

1.8 Organization of the dissertation.

Chapter 1: Orientation.

The chapter provides a background of health dangers associated with wood dust in a working place, statement of the problem, purpose of the study, research questions, rationale, limitations and definition of terms are also presented.

Chapter 2: Literature Review.

Provides a literature review of areas related to the research scope. This includes Health and Safety, graphics, design systems, constructability concepts and tools, and the current extraction systems and practices. The theoretical framework for the study is also presented.

Chapter 3: Research design and methodology.

The chapter describes the methods of gathering data leading to the Design-Build. Components of the research design and empirical data, research instruments, research population and sampling technique, research procedures, data presentation and interpretation and specifications are described in detail.

Chapter 4: Data analysis and interpretation of results.

This chapter describes how the data collected is analyzed and presented. The information is presented in tables with titles which describe the data.

Chapter 5: Researcher's design ideas of dust extractor and development of the Chosen idea.

The detailed analysis of various ideas and attributes presented provide a possible solution idea. How the idea was applied to extract dust to improve the working environment is described. The framework of the extractor design is presented. A general description and development of the dust extractor concept and the system architecture is presented.

Chapter 6: Model of dust extraction system.

This chapter presents the frame work of production schedule, main processes, modelling and manufacturing.

Chapter 7: Evaluation of product, main findings and recommendations.

Chapter 7 provides a closing for the dissertation. An evaluation of the realized solution and modifications are justified. A conclusion of the main learning outcomes is discussed in the document. The benefits and contributions of the research, along with recommendations for future research and extensions, are presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this literature review was to critically look at the existing research that is significant to enhancing learning through a safe environment in a technology workshop. This literature review provided the context for the research by looking at what has already been done in the area of the phenomena (Tuckman, 1998:38).

Worldwide, the incidence and severity of allergy and asthma is increasing (Mitka, 1999:3; Platts-Mills and de Weck, 1989:2). Wood is *known to be a human carcinogen*, based on sufficient evidence of carcinogenicity from studies in humans. A correlation between wood dust exposure and cancer of the nose has been observed in many case reports, cohort studies, and case control studies that specifically addressed nasal cancer. Strong and consistent associations with cancer of the nasal cavities and Para nasal sinuses were observed both in studies of people whose occupations are associated with wood dust exposure and in studies that directly estimated wood dust exposure (Demers and Boffetta, 1998:10).

At the beginning of the twenty-first century, subjects such as Craft Technology and Science played a valuable and important role in our school and colleges. There is evidence that learners developed reflective thinking through the integration and application of knowledge during learning activities in the workshops (Farrant, 1985:107). The hazards created by activities such as soldering, welding, wood and metal working and chemical experiments can not be overlooked. The fumes and dust created by these processes are extremely toxic. Learners and educators who would be exposed to fumes and dust for a long period of time could develop many serious medical complaints such as sinonasal cancer, bronchitis, and especially asthma, a condition already prevalent in children.

The research done by the International Agency of Research on Cancer, and Applegate, as well as Union Safe Organization Studies (1995:3) show that dust is a health hazard. Though Union Safe Organization Studies and International Agency of Research on Cancer, and Applegate studies refer to the dangers of dust in industries, the technology workshop in a school is a learning industrial environment which cannot be overlooked.

The fumes and dust created by these industrial processes are extremely toxic; they are a hindrance to learning and performance. For many years, wood dust was considered to be a nuisance that irritated the nose, eyes and throat, but did not cause permanent health problems. Numerous recent studies by the United Nations Environment Programme (UNEP) ,World Health Organisation and International Occupational Safety and Health Information Centres (ILO-CIS) hazard prevention and control in the work environment, however, have shown that exposure to wood dust can cause permanent health problems.(http://www.ilo.org/public/english http://www.unep.org/ Manahan:1997, Welch:1998, Woodside and Kocurek : 1993).

Fine dust produced by processes such as shaping, sanding, and routing generates higher exposure levels. Exposure to wood dust can be controlled through the use of appropriately designed ventilation systems or respiratory protection. The National Institute for Occupational Safety and Health (NIOSH) in the United States of America (USA) has developed guidelines for local ventilation systems for several types of wood working equipment such as horizontal belt sanders, shapers, automated routers, large diameter disc sanders, orbital hand sanders and table saws (NIOSH, 1987:37). Even with the use of recommended dust control techniques, it may not be practicable to prevent exposure to wood dust. If there is uncertainty about whether there is a risk to health from exposure to dust from wood products, air monitoring may need to be carried out. The risk to health needs to be assessed taking into account the nature of the work, duration of exposure and the control measures in place.

In the school environment, there are many different types of dust formed from wood, metal, synthetic fibres (e.g. fibreglass), ceramic art materials and textiles. These dusts can be created by a wide range of curriculum and maintenance activities performed by learners and staff in the Design and Technology workshop.

Dust (e.g. wood dust) can:

- Be an *irritant* that causes minor problems or may
- Trigger *allergic reactions* resulting in occupational asthma, rhinitis or other forms of respiratory distress.

Dust is usually generated by mechanical processes such as sanding, grinding and sawing. Schools may not have identified the potential health effects associated with some of these processes.

The School has an obligation to effectively manage all known risks to learners and staff associated with dust exposure. The control measures must ensure that the levels of dust particles in the air do not exceed national exposure standards/limits. This is usually achieved by:

- Assessing products and equipment to eliminate or reduce risks;

- Minimising the generation of dust during the process e.g. wetting down;
- Capturing dust at the point of generation e.g. extraction system on the equipment/machine; or
- Maintaining effective natural or mechanical ventilation systems in the room or workshop.

The development of a health and safe wellbeing framework is needed to enhance learners' wellbeing in the technology workshop and school as a whole. This initiative might enhance learners' morale and minimize stress in the workshop.

2.2 Theories underpinning the study.

The study was guided by the analysis of constructivism, behaviourism and cognitive theories of learning.

2.2.1 Constructivism.

Constructivists believe that "learners construct their own reality" or at least interpret it based upon their perceptions of experiences. An individual's knowledge is therefore a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events. What someone knows is grounded in perception of the physical and social experiences which are comprehended by the mind (Jonassen, 1994:5).
Constructivism traces its roots back to Socrates' dialogues with his followers. In this century, constructivism has evolved on the basis of Jean Piaget's and John Dewey's works. Lev Vygotsky, Jerome Bruner, and David Ausubel have added new perspectives to constructivist learning

theory. Many modern educators have studied and practised this approach to education. There are many different views within constructivism but they also hold many perspectives in common. Constructivists emphasize learning rather than teaching. Learning is an active process of searching for meaning. Meaning is internally constructed on the basis of experience. Thus, learning results from a personal interpretation of the world and it occurs in a social context. In spite of the fact that each person constructs a unique reality and there is no knowledge "out there" independent of the learner, we can still communicate and coexist.

Jonassen (1994:34) addressed this issue as follows: "A reasonable response is that issue of the Gibsonia perspective that contends that there exists a physical world that is subject to physical laws that we all know in pretty much the same way because those physical laws are perceivable by humans in pretty much the same way. Constructivists also believe that much of reality is shared through a process of social negotiation" (Jonassen, 1994:34). In constructivism, the learner has autonomy and initiative, the educator is a facilitator who supports the learner during construction of conceptual schema in the authentic environments, and the meaning is negotiated from multiple perspectives by communication.

2.2.2 Behaviourism

Behaviourism is a theory that focuses on observable behaviour and stimulus-response association in the external environment. A behaviourist defines learning as the acquisition of new behaviour, and it can only be measured by observing changes in behaviour. Behaviourist theory is based on the assumption that human behaviour can be predicted and shaped by appropriately manipulating the environment, and the belief that the change of stimulus and positively reinforcing the desired response elicit the learner's behaviour change and manipulating this environment ensures the learner to achieve effective learning. A learner is the subject who voluntarily responds to the stimuli. His/her role is to learn more complex behaviour, both passively and responsively. On the other hand learning is viewed as a change in behaviour due to experience Environment (E) which affects behaviour (B) (Farrant, 1995:108).

2.2.3 Cognitive theory.

Cognitivism arose from displeasure with the behaviourist notion that explains all human activities as response to reinforcement or punishment. Cognitivists believe that the learner also acts on the environment rather than the environment simply acting on the learner. They also believe a learner does not have to engage in any behaviour in order to learn. (Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. 1995). In cognitivism, learning is the acquisition of internal representations that may serve as guidelines for future guidelines, in which the learner decides if she/he engages. Cognitivism is an attempt to determine how information is processed in the mind and knowledge is constructed by the learner. Memory is key. (Reigeluth, C. M. 1999). New information builds connections to the existing schema and results in accretion, schema tuning, or schema creation. Cognitivism focuses on mental processes and basically "goes inside the head of the learner" to understand how people think, remember, solve problems, and act the way they do. Learning occurs in the mind of the learner, where information from the external environment is received, and processed, stored and retrieved when needed (Pressly, 1995:24). All learning processes are potentially under the control of the learner. The learning is influenced by the learner's prior knowledge and the feedback of instructional material that support the learner (Farrant, 1985:107).

Learning theories describe why and how learning occurs. The wide varieties of different learning theories were developed with connection to instructional design. According to Winn (1997:37), any successful practitioner or researcher needs to be thoroughly versed in at least the immediately underlying discipline to his or her own.

The theory of learning pathways described in constructivism, effectively relates to the situation environment in Design and Technology. The literature review on the theory of learning in Design and Technology processes were embedded in the constructivism theory of learning. The learning theory promoted student engagement and considered it to be a key component of knowledge construction, which relied on the learner to select and transform information construct hypotheses to make decisions and synthesize learning through personalizing knowledge.

Looking at the three theories of learning, Technology learning can be enhanced using constructivism, where learning activities are designed to encourage the individual learners to be active "constructors" of designs and activities. Learning has typically been a social activity for the simple reason that most human beings need to reinforce their beliefs and understanding by asking questions of others. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices.

2.3 Health and safety

According to the International School of South Africa, school health and safety manual on, maintenance workshop and Learners technical class - safety guide lines and inspection, the risk to health of learners in the workshop needs to be assessed taking into account the nature of the work, duration of exposure and control measures put in place (Health and Safety Manual, 1992:18).

The nature of wood-working is such that total elimination of wood dust from the work environment is not usually possible. However, the health risk associated with exposure to dust from wood products can be minimized through using a process or method of work that reduces the generation of dust to a minimum; e.g. using a plane instead of a sander to shape the wood or providing dust capturing equipment to all dust-producing processes; e.g. local exhaust ventilation at wood working machines and dust bags on tools maintaining plant and equipment in good condition; For example inspecting local exhaust ventilation systems regularly to ensure they are working efficiently and checking for holes and leakages in duct work. Dust control techniques must be put in place but, it may not be possible to prevent exposure to wood dust. If there is uncertainty about whether there is a risk to health from exposure to dust from wood products, air monitoring may need to be carried out.

The risk to health needs to be assessed taking into account the nature of the work, duration of exposure and control measures in place. Both the assessment and any subsequent consideration of control options must be carried out in consultation with relevant stakeholders, learners and any health and safety representatives. Dust is a big problem in workshops, as breathing in a lot of dust is a health hazard, and so the levels of dust in the workshop air have to be strictly controlled. In fact chapter11.1.1 Hazard Prevention and Control in the Work Environment of the Health and Safety at Work Act called the Control of Substances Hazardous to Health (COSHH) which specifically covers dust.(ILO Publications,164-165:1998) However the amounts of dust in a workshop can be limited by simple changes to work practices to minimize the level of wood dust in the workplace, to help manage the design and technology activities safely. For example , prevent accumulation of dust and wood chips by cleaning/emptying dust collection equipment regularly.

A school workshop is not a classroom, it is a very special environment covered by its own set of laws within the Health and Safety at Work Act. All school workshops are different, but most of them contain the same kinds of equipment, working areas and storage for hand tools and materials. There is a need to make the environment safe. Having a workshop clean and tidy will greatly reduce the risk of health and accidents.

There is growing concern for the negative effects the dust may have on learners' health and well-being, the quality of work, and the creativity and innovation needed in the design and technology. Young engineers, children and teachers(who will be exposed to fumes over longer periods of time)can develop many serious medical complaints that might compromise their performance. (Applegate Publication Manual, 2001:1) There is, therefore, a pressing need to monitor and research the 'changing world of work' and its impact on health and safety. To develop workshop organizational interventions to improve the learners' work environment. To eliminate risks to health or safety and to provide hazard free workplaces and learning environments. To minimize the occurrence of accidents and sickness and also to improve classroom performance. Improved dust extraction mechanisms to better the learners' working environment in the workshop is crucial. To ensure that all educators, learners, employees, customers and visitors are not exposed to any health and/or safety risks while they are in the workshop is necessary.

According to Shaws (2001:2) there are cases of school Design and Technology educators who have developed illnesses associated with working in a dusty environment in England. A Design and Technology educator in Nottinghamshire UK won nearly $250,000 compensation after being made ill by wood dust in the school's workshop. The 52-year old was forced to retire after 21 years as a head of department at the same secondary school when he began having headaches, nasal discharge and blockage, and rhino-sinusitis. The illnesses were directly linked to the wood dust he inhaled in the school workshop. The most damaging dust was from medium density fiberboard (MDF) which included particles of formaldehyde. Another, Mr. Eric McCreery, a Technology educator at Llanishen High developed occupational asthma after exposure to wood dust in the school workshop. He claimed that there was no dust extractor in the workshop (Shaws, 2001:2).

Willingdon School in Eastbourne is one of the many schools in UK that had an unsatisfactory working environment in the workshop. The educator complained that the school's workshop, over the 10 years he worked there, was dusty and dirty. There was no dust extractor. A survey was carried out followed by a full specification proposal and quotation. (Dust Control Publication, 2001:1)The two classroom and staff workshops with planing, sanding, saw benches, lathes, fretsaws, etc required a total air volume of approximately 3000cu.ft/ minute (5100 M3/hr) and a suitable filter was selected which contained 462 sq. ft of filter media resulting in a filter speed of 6.5 ft. / minute to ensure continuous full performance without cloth blinding, permeation of fine dust to the atmosphere and long life of filter elements. The filter contained a 7.5 kW fan set and 0.25 kW shaker motor with pre-separation chamber and explosion relief panel with the filter located external to the building. These where similar conditions experienced by Mr. Eric McCreery, a Technology educator at Llanishen High developed occupational asthma after exposure to wood dust in the school workshop. A complete new set of ductwork and capture hoods was installed. Since then the workshop environment has improved, providing a conducive learning and teaching environment.

It was with this in mind that the development of a health and safe wellbeing framework was needed to enhance learners' wellbeing in the technology workshop. The analysis of capturing dust at the point of generation e.g. extraction system on the equipment/machine was an initiative that might enhance learners' morale and minimize stress in the workshop.

2.4 General principles of system design

The purpose of this study was to investigate measures that could be taken to promote a safe, healthy and conducive learning environment in the Design and Technology workshop, how a dust extraction system could be designed to solve the problem of dust in the workshop? The general principles of a dust extraction system might assist in designing a workable dust extraction in the workshop.

The NIOSH guidelines use local ventilation hoods to capture wood dust which is then collected in a filtration system. Good general ventilation within a plant or workshop can reduce exposure to wood dust. Wood dust collecting within the building, on the floor, or on the equipment, means that the ventilation system is inadequate or is not working properly. Local ventilation may not be practical for some operations and in some cases the concentration of wood dust in the air cannot be adequately controlled by ventilation alone. In such cases respiratory protection may be needed if the Occupational Exposure Limit of 5mg per cubic meter for dust is or may be exceeded.

The American Society of Heating, Refrigeration and Air- Conditioning Engineers (ASHARE) (1999) have indicated optimum healthy ventilation requirements in a workshop environment. Dust control systems design and manufacturers have also stated that as a general standard the health and safety operators in industry must not be exposed to more than 5mg per cubic meter of fine dust Local Exhaust Ventilation Publication (LEV) 2005:2). To achieve an optimum dust extraction system the following should be considered:

- **Capture hood design**

The prime purpose of all pollution control plants which have hoods as an integral part of the system is to contain and entrain the generated dust and fumes. In all workshops, the position of the hood in relation to the dust and fume source dictates the extraction rate. (Local Exhaust Ventilation Publication (LEV) 2005:2).

- **Design criteria for dust collection**

An extractor fan is used to move the contaminated air from its source to the filtration device. The fan should be on the clean side of the filter to enable a more efficient impellor design to be used, thus lowering the energy consumption (Local Exhaust Ventilation Publication, 2005:2)

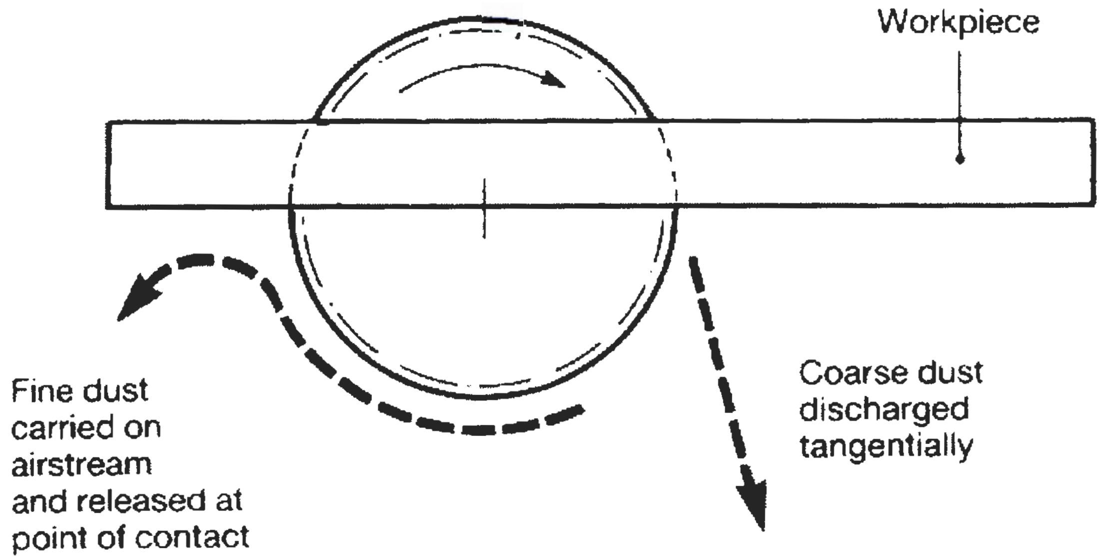
- **Extraction and filtering equipment**

The main objectives of an extraction plant are high collection efficiency of the filter fabric and the maintenance of an acceptable resistance through the filter material. If the resistance rises above a pre- defined design level, the extraction volume will decrease and the desired extraction performance will diminish. (Local Exhaust Ventilation Publication, 2005:2)

To design an efficient control system, firstly identify the emission point and mark every location on the workshop or plant layout drawing. Next determine the air volume required at each source by using the formula Q = VA, where Q is the volume (quantity) of air needed to produce a given in-draft velocity over a given area, V is the velocity (m/minute) and A is area (sq m). Decide what type of collection hood to use, based on your workshop's maintenance needs, operational considerations and the air flow volume required for capture. The two basic types of hoods are enclosing, which completely or partially processes all contaminants at the generation point; and exterior, which are located adjacent to an emission source without enclosing it.

When considering methods of control, it is important to consider the nature of the dust and the forces that influence its movement. Woodworking produces large quantities of both fine and large particles of both fine reparable dust and non reparable particles. Figures 1(a), (b) and (c) show the typical patterns of dust movement from woodworking machines.

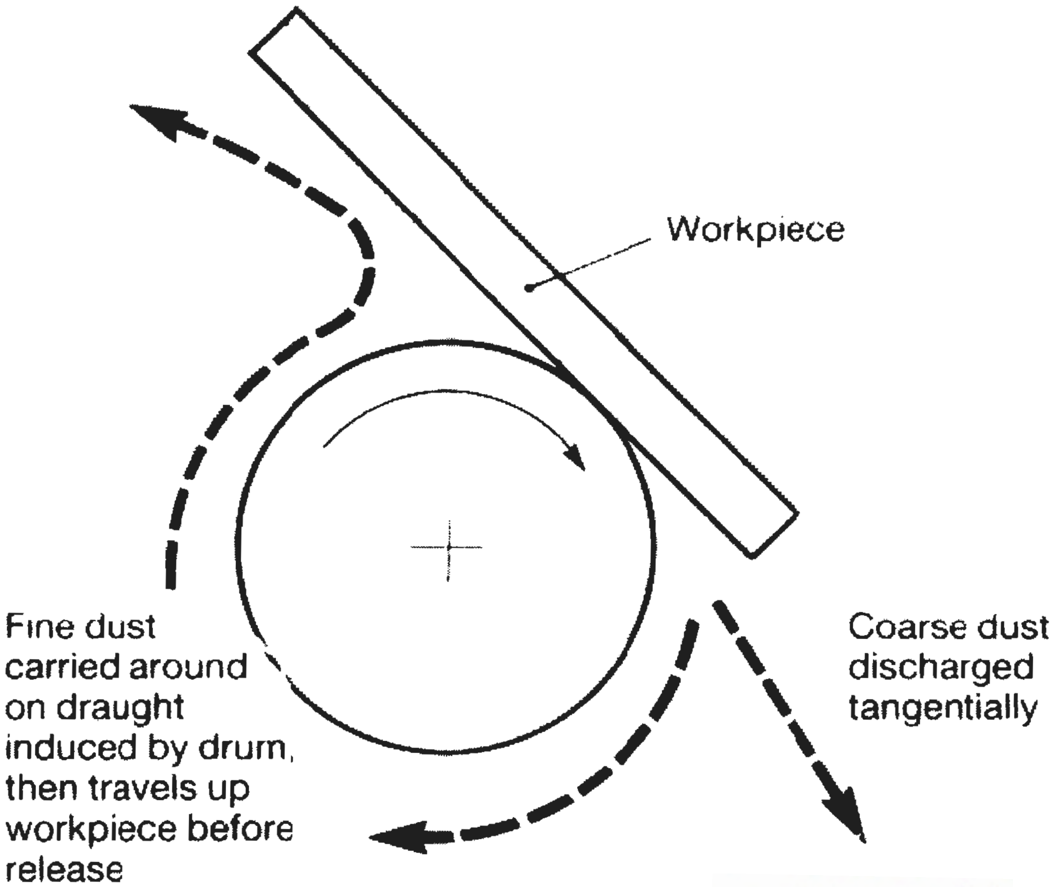
Figure 1(a): Sawing and cutting.



(Local Exhaust Ventilation Publication, 2005:2)

Fig 1a. shows how dust is released during the sawing and cutting process in the workshop with the coarse dust tangentially to the sanding disc and fine dust is carried on air stream and released into the workshop environment.

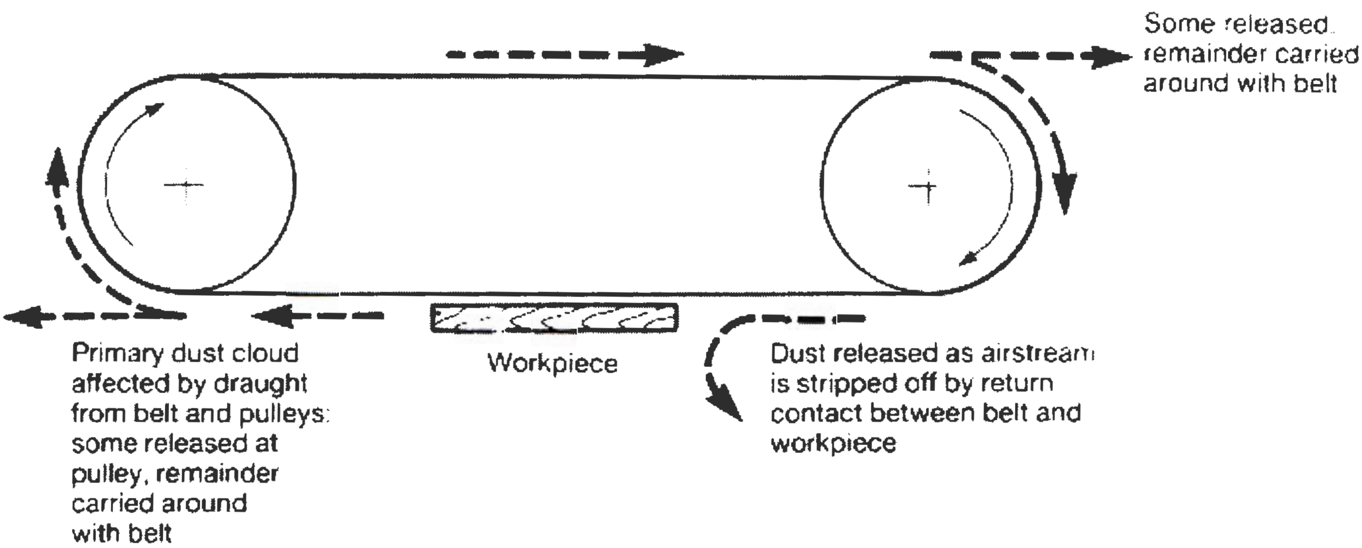
Figure 1(b): Drum sanding and abrading operations.



(Local Exhaust Ventilation Publication, 2005:2)

Fig.1b shows how dust is released during the sawing and cutting process in the workshop with the coarse dust discharged tangentially to the sanding disc and fine dust is carried around on draught induced by drum, and then travels up the work piece before it is released into the workshop environment.

Figure 1(c): Belt (pad) sanding.



(Local Exhaust Ventilation Publication, 2005:3)

Fig.1c shows how dust is released during the belt (pad) sanding process in the workshop with the dust being released as air stream strips off by the return contact between belt and work piece. The primary dust cloud affected by draught from the belt and pulleys is released and the remainder carried around and released at point of contact with the work piece into the workshop environment.

Coarse dust is carried by its own momentum and usually collects around the point of generation. Respirable dust quickly loses its momentum and is carried away in air currents making capture more difficult. The movement of machine parts such as cutters, revolving drums, driving pulleys, belts, etc will create considerable air movements and an efficient extraction system should be designed to use these air movements to maximum advantage.

2.5 Principles of design.

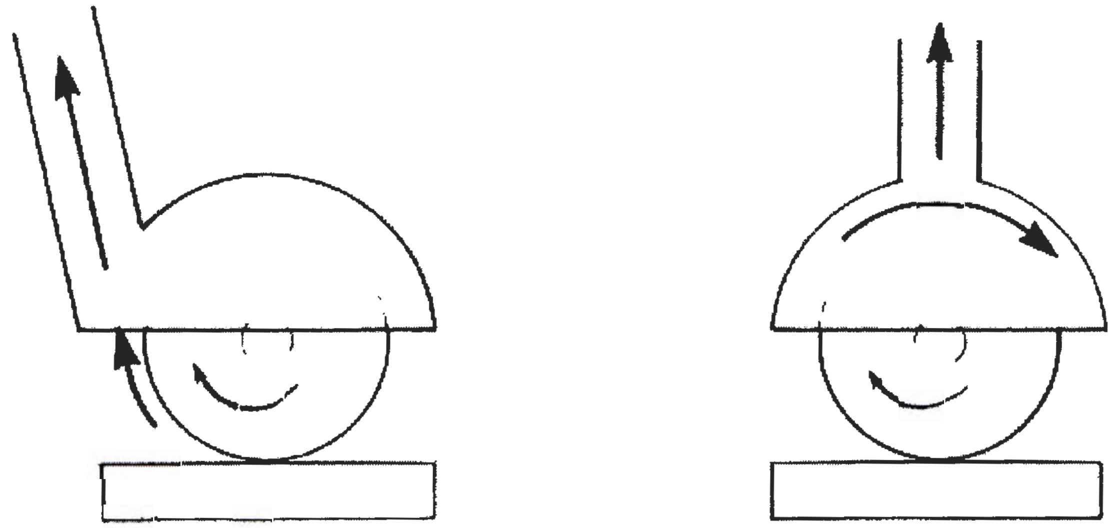
Poor workshop layout leads to excessive pipe lengths and numerous bends. This decreases the efficiency of the system and may lead to increased noise levels at some work stations. Ad hoc extensions to extraction systems should be avoided. No additional extraction points should be added unless the system is known to have the necessary extra capacity.

Points to consider in the design of exhaust ventilation systems for woodworking machines are:

- All moving parts of machinery should be enclosed as far as possible in order to minimize stray air currents.
- Captor hoods should be as close as possible to the point of dust generation and positioned to capture the dust laden air-stream. The greater the degree of enclosure of the source, the better will be the control. The addition of flanges around the exhaust inlet will considerably improve capture efficiency.
- Hoods and their associated connections should be designed so that they take advantage of, rather than work against, the natural air movement created by the machine (Figure 2).
- Turbulent airflow creates noise and reduces extraction efficiency. When the direction of airflow caused by the tool is different from that caused by the extraction system, the result can be increased turbulence in the airflow, loss of extraction efficiency and increased

noise. The use of extraction guide vanes will reduce turbulence (Figure 3).

Figure 2: Exhaust hood design.

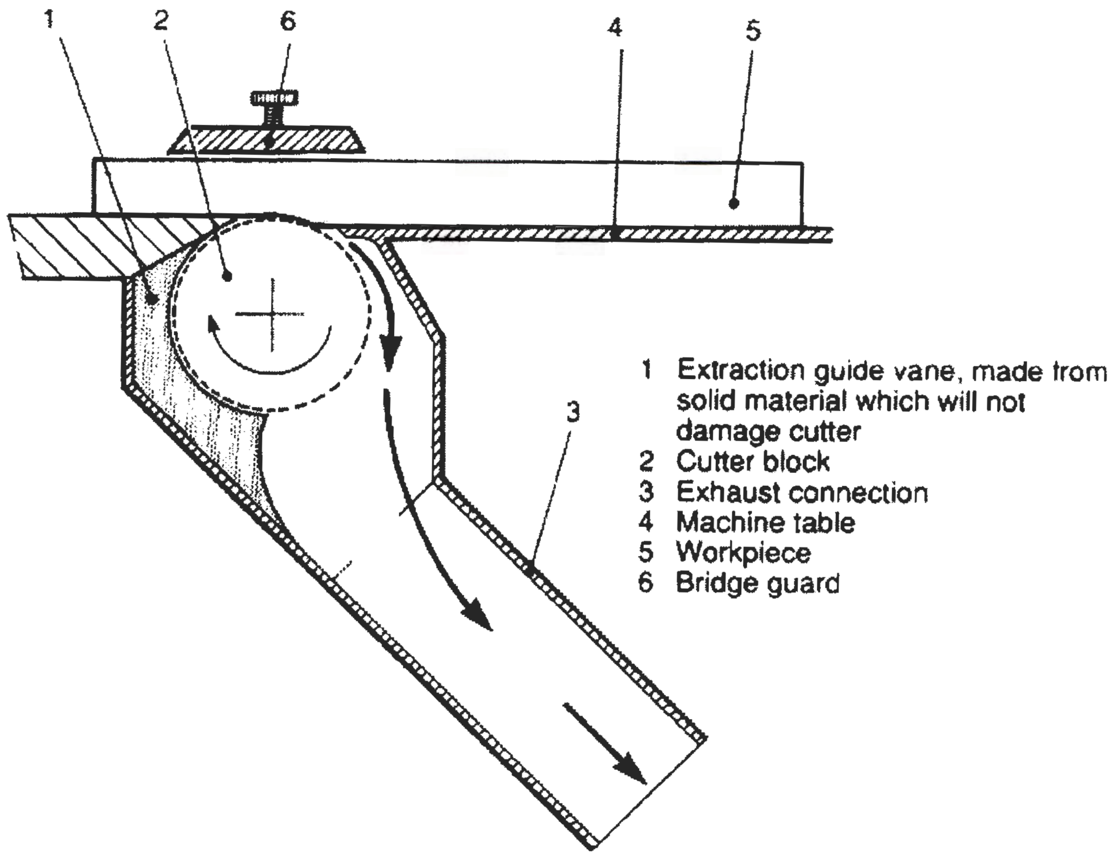


Good – exhaust hood positioned to take advantage of direction of air movement created by machine.

Poor exhaust an air movement from tool acting in different direction.

(Local Exhaust Ventilation Publication, 2005:3)

Figure 3: Surface planing machines



(Local Exhaust Ventilation Publication, 2005:3)

- Junctions in the system should be at small angles and internal flanges should not be used. Bends in the system should have large radii.
- The minimum air velocity necessary to keep dust and chippings airborne in ductwork etc is 20 m/s. The minimum number of hoods or inlets necessary to maintain this transport velocity through the system should be identified and steps should be taken to ensure that at least this number is kept open when the system is in use.

- The capture velocity necessary to draw the dust towards the exhaust inlet is measured at the source of the dust. Conversion from capture velocity to hood face velocity depends on hood design and its distance from the source. For most woodworking machines a capture velocity of 5 m/s will be adequate, but capture velocity should reflect the air flow conditions at the point of capture and velocities of up to 10 m/s may be needed under particularly arduous conditions.
- Any local exhaust ventilation system which has more than one inlet will need to be balanced so that each branch extracts just the right amount of air through the inlet it serves. The airflow in each branch will be determined by the resistance of the inlet, the length, diameter and flow resistance of the branch duct and the flow conditions at the junction with the main duct.

2.6 Air movers and collection units.

When selecting an air mover or fan, factors which will need to be considered will include the total airflow required, the overall resistance of the system, expected noise levels and limitations of space. Fans and air movers should ideally be sited outside the workroom and should be regularly maintained in order to reduce their impact on workplace noise. Where possible, air cleaners and collection units should be situated in the open air away from main thoroughfares or places regularly frequented by people. Wood dust from most machining processes will contain an exposable fraction and the setting and design of air cleaners and dust collectors must take this into account. Where necessary, units should be enclosed and fitted with adequate explosion relief which will vent to a safe place should an explosion take place.

2.7 Commissioning, inspection and maintenance.

Commissioning is the formal procedure used to bring the local exhaust ventilation (LEV) system into use after it has been installed. The system should be proved to be capable of meeting its design specification. Appropriate details of airflow velocities and pressures should then be recorded to provide standard performance data for future reference.

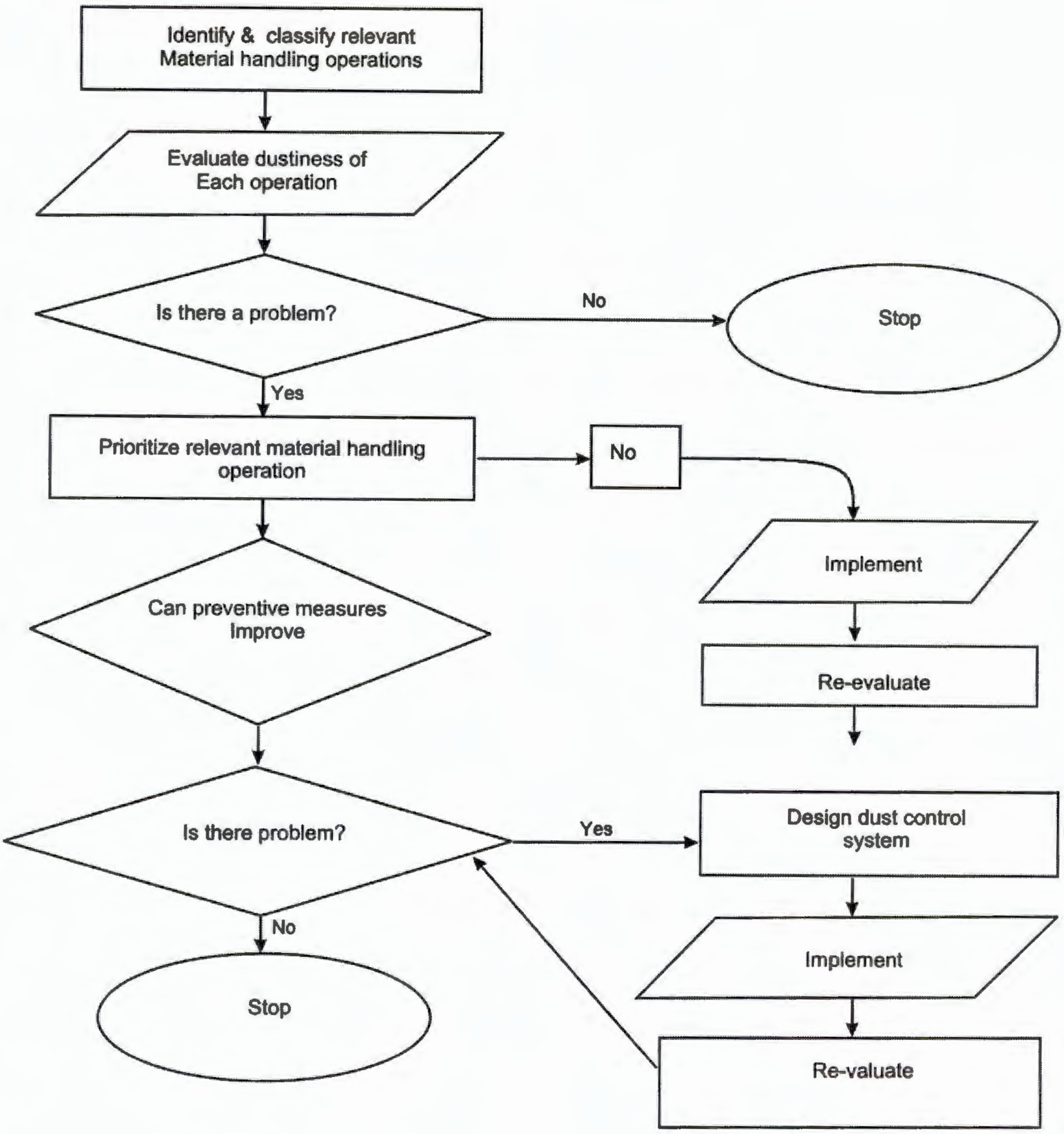
Once installed, LEV should be regularly checked for leaks or blockages. Leaks and deficiencies in extraction systems can be found using a dust lamp. LEV must be thoroughly examined and tested at least once every 14 months by a competent person.

The efficiency of the system will also be affected by the condition of the filter in the collection system. Filters will need to be shaken several times during the working day and will need to be thoroughly cleaned at regular intervals according to the manufacturer's instructions (LEV Publication, 2005:3)

2.8 A systematic approach to dust control.

Effective dust control demands a systematic approach. This approach outlined in Figure 4 identifies and classifies relevant material handling operations. The dustiness of each operation should be evaluated. This can be based on direct measurement with visual or light scattering techniques, review of similar operations, and observation by plant personnel. Prioritize the material handling operation for dust control based on time, cost and feasibility constraints.

Figure 4: A systematic approach to dust control



(Gardiner and Harrington, 1998:58)

Consider preventive dust control measures. Dust emissions occur through the interactions of the process operation, the material, and air dispersion. The process operation detaches small particles from bulk materials and exposes these particles to the air currents which disperse the dust. Three items can be modified to prevent the formation of dust. Process modifications can be eliminating an operation or changing the operation to minimize grinding and falling actions reduce dust formation by that produce dust. The effectiveness of the preventive measures should be re-evaluated after their implementation. Often preventive measures must be supplemented with dust control. The most effective dust collection or suppression system must be selected and designed.

- Material modification can reduce the dust hazard by substituting one material for another that produces less dust or less toxic dust, or by changing the material's properties by adding water or other chemicals to produce less dust.

- Air dispersion can be minimized by enclosing the material to reduce air currents or by segregating the dust source from areas with workers. Enclosing the material includes covering a source with tarpaulins, building a wind screen with trees, or surrounding a source with walls (LEV Publication, 2005 :4)

2.9 Summary

Reviewing the whole major focus of learning process in Design and Technology, little has been done to enhance health and safety of the learning environment in the school workshops. The dust extraction systems in school workshops are portable systems which only extract large particles of dust in the working area and not the fine dust which learners often complain about during learning activities. The chapter revealed the learning processes, health and safety and the major design aspects of an ideal dust extraction mechanism for the Design and Technology workshop.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter outlines the methodology used to carry out the research study such as the population, sample and sampling procedure , research instruments, administration, collection of data, the validity and reliability of the research and the analysis of the collected data.

3.2 Research design

The study used both qualitative and quantitative research approaches. A qualitative approach is one which involves methods of data collection and analysis that are non-quantitative. Myers (1997:59) contends that a quantitative approach is one which deals with numbers whereas a qualitative approach helps the researcher to understand people and the context within which they live. The qualitative approach was used to collect information on the usage of machines and how the dust was produced. The quantitative approach was used to measure the effect of wood dust on learners' performance in the technology workshop, to provide a healthy and safe working environment.

A case study method was used in this study. A case study is 'an umbrella' term for a family of research methods having in common the decision to focus on inquiry around an instance(Bell, 1999:10).The case study method was used because the researcher wanted to concentrate on the situation of dust to provide a safe environment in the workshop. According to Bell (1999:10). The case-study method is particularly appropriate for individual researchers because it gives an opportunity for one aspect of a problem to be studied in some depth within a limited time scale though some case studies are carried out over a long period of time. Therefore, the aim of the case-study research was to identify dust environment features in the technology workshop, how they hinder performance and affect the health of learners. It would further assist with or suggest or recommend the installation of a dust extraction system that will provide a safe and healthy learning environment in the technology workshop.

3.3 Population

Fowler (1993:44) indicates that a population is a large group of individuals to whom the results will be generalized. Fowler further refers to what is called a sampling frame, which is the group from which the actual sample will be drawn. The study was carried out at the International School of South Africa (ISSA) in Mafikeng, North West Province. The school had a total number of 290 learners and 30 educators. The researcher was interested in studying the effects of dust during learning activities in the Design and Technology workshop. There were 205 learners doing Design and Technology from Form 1- Form 6 (A' levels), 30 educators and 20 permanent ancillary staff.

Table 1: Population from which sample was taken

Form	Number of learners
2 Form 1 classes	40
3 Form 2 classes	60
3 Form 3 classes	60
1 Form 4 class	20

1 Form 5 class	15
1 Lower 6 class	5
1 Upper 6 class	5
Total	205

3.4 Sampling and sampling techniques

It is important to select a sample for research purposes mainly because it is difficult to get in touch with all the people within a selected population. Besides, not all people who constitute the population are relevant to the research focus. According to Fowler (1993:45) sampling means selecting a given number of subjects from a defined population as representative of that population. This means that the results of data from the sample may not be generalized outside the population from which the sample was taken. The study used purposeful sampling to select the sample. According to Cohen and Manion (1992:103) purposeful sampling entails selection of respondents for a particular purpose. For this study respondents were required to provide specific information on specific issues pertaining to health and learning in the workshop.

The researcher used purposive sampling, where he chose the participants to be included in the sample on the basis of previous knowledge and purpose of the research. In this way, the researcher built up a sample satisfactory to provide the desirable information about the research problem. Researchers assume they can use their knowledge of the population to judge whether or not a particular sample will represent the population (Frankel and Wallen, 2000:112). The sampling technique enabled the researcher to establish how the learners and staff saw the conditions of the working environment in the workshop.

The Design and Technology section has 3 laboratories/workrooms, the manufacturing laboratory, electricity/electronics laboratory and the graphics design laboratory. The Design and Technology scheme of work for learners is as follows: In form 1 it is basically introduction to design and technology theory, knowledge of tools and making models out of cardboard. In form 2 it is resistant materials, manufacturing processes and machines. In form 3 it is electricity /electronics theory, structures and making models out of cardboard and paper. In forms 4 and 5 it is the design process, theory and practice while in form 6 it is product design.

The researcher used all Form 2 classes as the sample with a total number of 60 learners. In these classes learners were diverse in the activities and optimum usage of machines in learning skills and processes in the manufacturing workshop. These processes of manufacturing produced a considerable amount of smoke and wood dust in the workshop. This is a health and safety hazard to the learners. This sample of 60 learners represented 29.3% of the total Design and Technology learners. The staff sample comprised of 8 educators in the faculty from a total of 30 educators and 8 ancillary workers in the maintenance department from a total of 20 ancillary workers of the International School of South Africa (ISSA). The samples represented 26.7% and 40% of the total number of educators and ancillary workers respectively. This group was chosen because they were directly involved in the school health and safety and wellbeing of the learners and educators in the whole school. .

3.5 Research instruments

The study made use of questionnaires, interviews and observations for collecting data. The use of these techniques and procedures followed are discussed below. Research instruments allow researchers to draw accurate conclusions about subjects being studied. Instrumentation involved not only the selection or design of the instrument but also the condition under which they would be administered. According to Borg and Gall (1989:430), questionnaires and interviews are the most common instruments for data collection in research.

3.5.1 Questionnaire

A questionnaire was used as one of the instruments to collect data from learners in this study. According to Walonick (1993:23) a questionnaire is one of the most popular methods of conducting scholarly research. It provides a convenient way of gathering information from the target population. In this study, the researcher gave the questionnaires to learners in the last 10 minutes of the lesson. The formulation of the questionnaire was guided by the research questions and theoretical framework of the study. The structure of the questionnaire was open-ended. Open-ended questions allow respondents to include more information, including feelings, attitudes and understanding of the subject. This allows the researcher to better access the respondents' true feelings on the issue. Closed-ended questions, because of the simplicity and limit of the answers, may not offer the respondents choices that actually reflect their real feelings. Closed-ended questions also do not allow the respondent to explain that they do not understand the question or do not have an opinion on the issue. The questionnaire was simple and of direct language so that Form 2 learners could understand, not misunderstand and misinterpret the questions that ultimately could affect the reliability and validity of the data collected. The short coming of learners not completely being honest in providing responses was, however, reduced by in-depth interviews.

3.5.2 Interview

In this study individual structured interviews were used as a technique for data collection, from educators and ancillary staff (See Appendix B). The educators and ancillary staff agreed to have the interview recorded for transcription later. The question and answer session, was designed to obtain in-depth qualitative information. The interviews were recorded. These focus groups, composed of six educators, six ancillary staff and six learners' representatives were useful in conducting exploratory research. In these groups respondents were asked questions and response recorded. However, Rubin and Rubin (1995:140) caution that this type of technique requires being watchful on those respondents who may be talkative and those that are afraid to speak.

Structured interviews were helpful in exploring the circumstances and effects of wood dust in the work area in the Design and Technology workshop. The International School of South Africa (ISSA) maintenance staff and educators were interviewed. The total number of interviewees was 18. The interview question sheet consisted of ten questions (not more than 30 minutes) to elicit more information on the layout, setting and impact of dust on the educational environment in the workshop. The purpose of the questions was to determine the degree of performance of learners during workshop practice and how the staff felt about the dust in the Design and Technology workshop.

3.5.3 Observation

An observation is an action of noticing or watching, which is recorded in some way. If you observe a meeting or a group as part of your investigation, make efforts to place what you see in its organizational and/curricular context and look beyond the event itself (Bell, 1999:166). This was done to get an in-depth knowledge of how learners used the machines and the frequency of use in the Design and Technology workshop during their learning activities (See Appendix C). The researcher made the observations during lessons in the 3 Form 2 classes. The purpose of the observation was to probe deeply and to analyze intensively usage of machines and the effects of dust during learning processes in the Design and Technology workshop. Also to establish the modalities of the need for a dust extractor in the workshop.

3.6 Reliability and validity

Validity refers to the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. While reliability is concerned with the accuracy of the actual measuring instruments or procedure, validity is concerned with the study's success at measuring what the researchers set out to measure (Carmines and Zeller,1991:12). By making the purpose of questions less obvious, the indirect approach is more likely to produce frank and open responses. Specific questions like direct ones may cause a respondent to become cautious or guarded and give less than honest answers. Non specific questions may lead circuitously to the desired information but alarm less the respondents, increasing the chances of more reliable results in the study. Increased reliability of the interview is brought about by greater control of its elements. This is achieved at the cost of reduced validity. In proportion to the extent of which 'reliability' is enhanced by rationalization, validity decreases. The main purpose of using an interview in research is that it is believed that in interpersonal encounters people are more likely to disclose aspects of themselves, their thoughts, their feelings and values than they would in a less human situation. At least for some purpose it is necessary to generate some kind of conversation in which the respondent feels at ease. In other words the distinctive human element in the interview is necessary to its 'validity.' The more the interviews become rational, calculating and detached, the less likely the interview is to be perceived as a friendly transaction and the more calculated the response is likely to be. Reliability and validity of observation concerns human nature and in particular the relationship between human beings and their environments. Since the human being is both subject and object of study (Kimbell, 1999:343).

Triangulation: Triangulation is a multi-method approach which is cross-checking the existence of uncertain phenomena and the veracity of individual accounts by gathering data from a number of informants and a number of sources and subsequently comparing and contrasting one account with another in order to produce as full and balanced a study as possible (Open University course E811 (1988:54). The use of the three data collection techniques questionnaires, interviews and observations may also be referred to as triangulation. The researcher used a combination of these techniques for triangulation in the study.

3.7 Data analysis, interpretation and presentation

The quantitative and qualitative data analysis methods were used in this study. For the quantitative analysis the researcher relied solely on the Statistical Package for Social Sciences. For the qualitative part, Mile and

Huberman (1994:7) argue that data analysis consist of three concurrent activities that is, data reduction, data display and data verification. Information collected about health and safety of learners in the Design and Technology workshop was explored and therefore described. This data provided an overview of learning activities taking place in the workshop. As for the interviews, data collection proceeded simultaneously with data analysis. The interviews were recorded for transcription later. The interviewees obliged to the recording of the interviews as they felt it would help improve the learning environment in the workshop.

CHAPTER 4

DATA ANALYSIS AND INTERPRETAION OF RESULTS

4.1 Introduction

This chapter reports on the analysis of the results of the investigation conducted to find out what measures might be taken to promote a safe and health learning environment in the Design and Technology workshop at the International School of South Africa (ISSA).

4.1.1 Presentation of the results

The questionnaires from the learners, interviews from the educators and ancillary staff and observations made by the researcher were the sources from which the data of the research was derived. The research findings from these sources were presented in the form of tables, followed by a brief discussion.

4.1.2 Analysis and interpretation of results

This research study combined both qualitative and quantitative research methods in the analysis of the responses given by Form 2 learners, staff and observations by the researcher. Qualitative research techniques were used to analyze research data from questionnaires which could not be expressed in numbers. Quantitative research techniques were used to analyze research data form structured questions.

The advantages of using quantitative analysis as indicated by Trochim (2000), is that it is objective, and it is believed that in gaining, analyzing and interpreting quantitative data, the researcher remained detached and objective. The structure of some of the questions in the questionnaire, interview and observation was that the results from the findings could be quantified; hence it was easy to apply the quantitative method. However, quantitative analysis was not able to bring about more details of the research study about enhancing the safety and healthy environment in the Design and Technology workshop. Hence, the qualitative method was used to explain and interpret quantified information obtained from the learners.

According to Maxwell and Kaplan (1994:34), Qualitative analysis basically involves interpretation of a given text corpus, e.g. an educator-learner dialogue. The dimensions of this interpretation depend on the specific interest of the researcher and on the research questions asked. Maxwell and Kaplan went on to say that qualitative analysis allows researchers to seek relationships between various factors that have been identified, or to relate effects of an unhealthy and unsafe working environment of the learners. It also allows the implications for health and safety policy or practice to be derived from the data, or interpretation of findings from previous studies. Qualitative analysis ultimately allows theory to be developed and tested using analytical techniques. Qualitative analysis also generates detailed and valid data that contributes to an in-depth understanding of the context in which the phenomenon under study took place.

4.2 Results and analysis

The researcher handed out a questionnaire before the end of the class. The procedure allowed the researcher to draw accurate, valid and reliable conclusions about the subject being studied. This guaranteed 95%

return of questionnaires for maximum data analysis. All the answers were analyzed both qualitatively and quantitatively in the study. The questionnaire required the learners to respond about the situation of health and safety in the workshop. The final part was open for the learners' free reflective responses about their likes and dislikes and what they would do to change/improve the situation of heath and safety in the workshop. The sample comprised sixty learners from three Form 2 classes, six educators and six ancillary staff.

4.2.1 Workshop guidance with regards to protective clothing.

The respondents were asked to respond to the following question;

"Do you receive any guidance with regard to protective clothing before entering the workshop? Yes/no"

Table 2: Workshop guidance.

Guidance	Frequency	Percentage
Yes	60	100
No	0	0
Total	60	100

Results on student guidance in the workshop of respondents are displayed in table 2. All learners 60 (100%) indicated that there was some form of guidance with regards to protective clothing before entering the workshop. This was so because it was a rule to wear safety clothing before entering the workshop. Also there was a notice for all learners to see before wearing the workshop safety aprons and as they entered the workshop on the door.

4.2.2 Frequency of reminder in the workshop

The respondents were asked to respond to the following question;

"How often is the reminder on safety in the workshop"

Table 3: Reminder about protective clothing in the workshop.

How often is the reminder on safety in the workshop	Frequency	Percentage
Always	60	100
Sometimes	0	0
Total	60	100

How often the respondents receive guidance is displayed in table 3. All respondents indicated that they always received guidance on wearing protective clothing before entering the workshop. This was so because it was a rule to wear safety clothing before entering the workshop. Also there was a notice for all learners to see before wearing the workshop safety aprons and as they entered the workshop on the door.

4.2.3 Times the workshop is used per week

The respondents were asked to respond to the following question;

"How many times a week do you use the workshop"

Table 4: Times learners work in the workshop per week.

Times respondents used the workshop per week	Frequency	Percentage
Once	56	93.3
Twice	4	6.7
3 times	0	0
Total	60	100

The number of times students used the workshop per week are displayed in table 4. Among the 60 respondents to this question 56 (93.3%) of the learners indicated that they worked in the work shop once a week and 4 (6.7%) twice a week and none indicated more than 3 times a week. The larger percentage of the learners attended technology workshop lessons as scheduled on the timetable. The 6.7% is the percentage of learners who in addition to the scheduled time, worked in the workshop to perfect their abilities in design and technology and also those who were slow learners to catch up on their project work .

4.2.4 Time spent in the workshop

The respondents were asked to respond to the following question;

"How much time do you spend in the workshop"

Table 5: Time spent in the workshop.

How much time is spent in the workshop	Frequency	Percentage

80 minutes	56	93.3
120 minutes	4	6.7
Total	60	100

The time spent in the workshop are displayed in table 5. Among the 60 respondent to the question 56 (93.3%) of the learners indicated that they spent 80 minutes working in the work shop 4 (6.7%) indicated 120 minutes. The majority of students spent 80 minutes in the technology workshop as scheduled on the timetable. The 6.7% of the learners who in addition to the scheduled time, worked in the workshop to perfect their abilities in design technology and also those who were slow learners to catch up. The workshop was a mini industry which produced effluents which were harmful to the health and safety of the learners. Any time spent in the workshop was a health and safety hazard if the workshop was not equipped with any form of health and safety protection.

4.2.5 Frequency at workshop and health problems

The respondents were asked to respond to the following question;

"Do you think the frequency at which you are exposed to the dust in the workshop will cause a health problem?"

Table 6: Frequency at workshop and problems

Frequency at workshop and problems	Frequency	Percentage
Yes	56	93.3
No	4	6.7
Total	60	100

The health problems frequency is displayed in table 6. Among the 60 respondents to the question 56 (93.3%) of the learners felt that the frequency of exposure to the dust in the workshop ultimately caused health problems while 4 (6.7%) felt otherwise. The larger percentage represented those learners who had excused themselves to go out of the workshop for various problems.

4.2.6 Experience of health problems

The respondents were asked to respond to the following question;

"Do you experience health problems due to the dust produced in the workshop?

Table 7: Health problems.

Experience health problems	**Frequency**	**Percentage**
Yes	56	93.3
No	4	6.7
Total	60	100

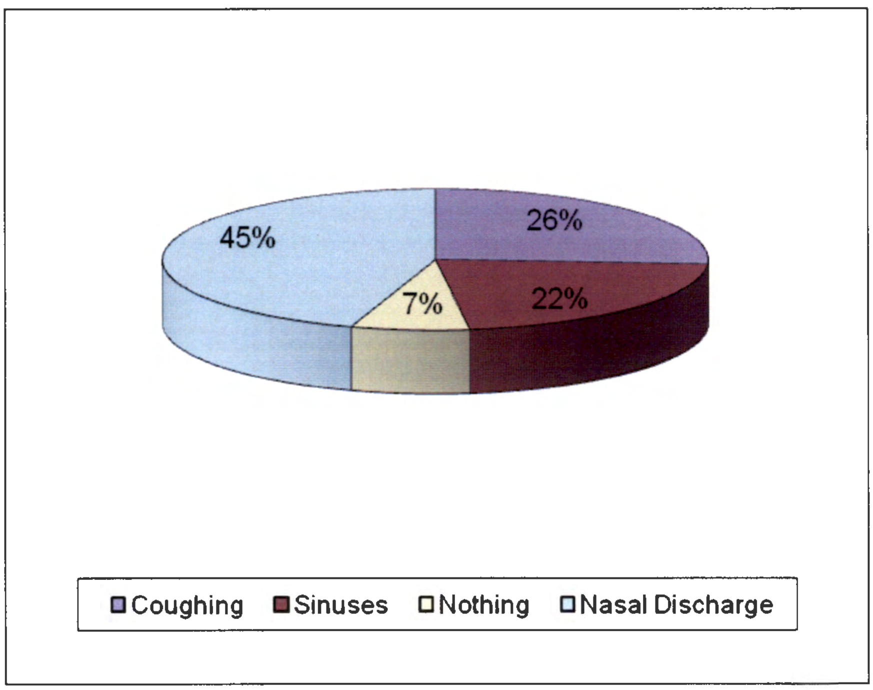
Experiences of health problems are displayed in table 7. Among the 60 respondents to the question 56 (93.3%) indicated that they experienced health problems due to the dust produced while in the workshop whilst 4 (6.7%) indicated that they experienced no health problems at all. The larger percentage represented those learners who had excused themselves in the workshop for various health problems.

4.2.7 Sickness problems experienced

The respondents were asked to respond to the following question;

" Which major problems do you experience, mention at least three major ones"

Figure 5: Sickness problems experienced by respondents



The problems experienced by learners are displayed in Fig 5. Among the 60 respondents to the question on sicknesses experienced, coughing due to dust, nasal discharge and sinus where the common problems experienced. Twenty seven (45%) of the learners indicated that they had nasal discharge problems, 16 (26.7%) indicated coughing problems, and 13 (21.7%) mentioned sinuses problems for which they had to seek attention at the school medical centre and 4 (6.7%) indicated that they experienced no problems all. This is probably because every learner is unique and they respond differently to stimuli in the environment.

4.2.8 The workshop is a risk to your health and safety?

The respondents were asked to respond to the following question;

" The workshop is a risk to your health and safety"

Table 8: Workshop health risk.

Workshop is a risk to your health and safety	**Frequency**	**Percentage**
Agree	49	82
Disagree	5	8
Not sure	6	10
Total	60	100

The workshop health risks are displayed in table 8. Among the 60 respondents to the question 49 (82%) of the learners agreed that the workshop was a risk to their health and safety, 6 (10%) were not sure and 5 (8%) disagreed that the workshop was a risk to their health and safety. Most learners were concerned about their health and safety in the Design and Technology workshop.

4.2.9 Who cleans the workshop at the end of the period?

The respondents were asked to respond to the following question;

"Who cleans the workshop at the end of the period?"

Table 9: Cleaning the workshop.

Who cleans workshop?	Frequency	Percentage
Learners	2	3.3
Educators	0	0
Cleaning staff	58	96.7
Total	60	100

The people who cleaned the workshop are given in table 9. Among the 60 respondents to the question 58 (96.7%) of the learners mentioned that the cleaning staff cleaned the workshop, 2 (3.3%) indicated that it was the learners and none of them mentioned the educators.

4.2.10 Does the workshop have a dust extraction machine?

The respondents were asked to respond to the following question;

"Does the workshop have a dust extraction machine?"

Table 10: Availability of dust extraction machine in the laboratory.

Is there an extraction machine?	Frequency	Percentage
Yes	0	0
No	60	100
Total	60	100

The availability of the dust extraction machine is displayed in table 10 above. All the 60 (100%) respondents to the question on the availability of a dust extraction machine indicated that there was no dust extraction machine in the workshop.

4.2.11 Will the installation of a dust extraction machine reduce the health hazards in the workshop?

The respondents were asked to respond to the following question;

"Will the installation of a dust extraction machine reduce the health hazards in the workshop?"

Table 11: Installation of dust extraction machine will reduce health hazards in the workshop.

Will installation of a dust extraction machine reduce health hazards in the workshop?	Frequency	Percentage
Most definitely	45	75
Definitely	12	20
Not sure	3	5
Total	60	100

The results regarding the installation of the dust extraction machine from the respondents are displayed in table 11. Among the 60 respondents who answered the question on whether the installation of a dust extraction might reduce the health hazards in the workshop 45 (75%) of the learners mentioned that most definitely the installation of a dust extraction machine would reduce the health hazards in the workshop, 12

(20%) were definite and 3 (5%) were not sure whether this would reduce the health hazards in the workshop.

4.2.12 Responses to question 13.

Learners were asked to the question stated below;
"How else can the workshop be improved for effective teaching and learning to take place? Mention at least two suggestions."

The learners suggested the installation of dust extractors and the use of vacuum cleaners. With respect to suggestions of how to improve the workshop for effective teaching, 38 (63.3%) suggested that installation of a dust extraction machine in the workshop would improve the teaching and learning environment in the workshop and 22 (36.7%) suggested the use of a vacuum cleaner to improve the teaching and learning in the workshop.

The majority 45 (75%) of the learners in Design and Technology confirmed their dissatisfaction with the dust in the workshop. Clearly the learners would like to have a dust extractor installed in the workshop. They also expected the installation of the dust extractor to improve the condition of the working environment in the workshop which might enhance their performance in Design and Technology.

4.2.13 Interview with Staff:

The respondents were asked to respond to the following question;

1. Researcher: Does the workshop have any guidance with regards to health and safety?

Interviewee: *The workshop has a safety notice with regards to rules and regulations in the workshop.*

2. Researcher: What health problems will the dust cause to educators and learners?

   Interviewee: *Some of the problems caused by dust are skin irritation asthma, itching eyes, coughing sinuses.*

3. Researcher: Do you think the dust produced in the workshop is a health hazard to learners and staff?

   Interviewee: *The dust in the workshop is a health hazard to both learner and staff. This can cause health problems.*

4. Researcher: Is the workshop a risk to the health and safety of learners and staff? Cleanliness in the workshop – when is it done?

   Interviewee: *Even though the workshop is cleaned only large particles of dust are removed. The fine dust is seen on window seals and machine parts are a risk to the health and safety of learners.*

5. Researcher: Do you have any casualties as a result of the dust?
   Interviewee: *There have been instances where learners have gone to the medical centre for treatment because of the dust in the workshop.*

6. Researcher: Has anyone ever raised a concern about this problem to the management of the school?

Interviewee: *Learners and educators have raised the issue with management, but since there is no follow up especially by the educators involved nothing was done to improve the condition of health and safety in the workshop.*

7. Researcher: Does the workshop have a dust extraction machine? Will the installation of a dust extraction machine reduce the health hazards in the workshop?

   Interviewee: *The workshop should be fitted with any form of dust extraction machine to reduce the hazard of dust and improve the learning condition of the workshop.*

8. Researcher: How else can we improve the health and safety in the school workshop?

   Interviewee: *The design of any model dust extraction from the dust source can help alleviate the problem of dust in the workshop which can thus enhance the learning and performance of learners.*

This was an example of one complete interview with one staff member.

The observations showed that when the learners engaged in the manufacturing processes of sanding and turning, that is when they started coughing and raised other complaints about dust. Even though the learners worked, it was because they had no choice, but they frequently asked for permission to go to the bathroom or medical centre for treatment. After the lesson some of the learners would complain about sore eyes, coughing, nasal discharge and skin irritation. The fine dust settled on machine parts and window sills. The workshop was not so big and the windows were high up for ventilation. The workshop was a high risk health and safety hazard to both the learners and the educators. The marking out process produced no dust, but the dust from the other processes affected the learners as they carried out these activities. This observation indicated that learners would benefit if a dust extractor was installed to remove dust at source in the workshop. This would reduce the risk of health and safety of learners in the workshop.

4.2.14 Summary

The educators, learners and staff confirmed their dissatisfaction with dust in the workshop. They clearly indicated that there was a need to improve the health and safety of the workshop environment. Clearly they would like to have a dust extractor installed in the workshop. They also had expectations that this would improve the condition of the working environment in the workshop which would enhance the learners' performance.

CHAPTER 5

RESEARCHER'S DESIGN IDEAS OF THE DUST EXTRACTOR AND THE DEVELOPMENT OF THE CHOSEN IDEA

5.1. Introduction

Design and Technology and its predecessors such as Woodwork and Metalwork have traditionally been integral parts of the school curriculum. The International School of South Africa Technology Workshop is equipped with tools and equipment that present high levels of risk beyond those in other areas of the school curriculum. Because the safety and welfare of learners and staff are of paramount importance, school councils, principals and technology educators must ensure that proper safety measures are taken. In addition to the professional obligation, the technology educator owes to the learners, there is a legal duty of care for the principals and educators to take such measures as are reasonable in the circumstances to protect learners in their care from risks of injury and other health matters that the educator should have reasonably foreseen. This chapter analyses ideas and attributes of designs to extract dust and provide a safe working environment in the Design and Technology workshop.

Figure 6: Layout of the Design and Technology Workshop

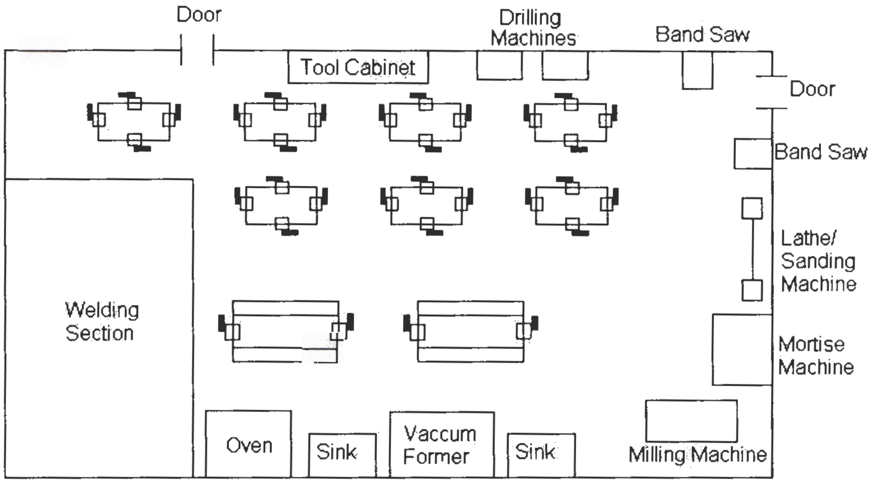


Figure 6 shows the layout of the Design and Technology Workshop. The work benches for the learners are in the middle and all the machines used in the processes of manufacture are placed along the walls in the workshop. The positions of the machines and work benches for learners in the workshop are such that the dust from the machine works went directly to the learners within the workshop. The dust from operations on the following machines in the workshop: drilling machines, band saws, lathe/sanding machine and milling machines poses the greatest risk/danger to the learners.

The researcher analyzed four different design ideas which could possibly be used to extract dust from a working area in the Design and Technology Workshop. The analysis culminated in the selection of one suitable idea for development and manufacture. A typical local exhaust ventilation system is composed of five parts: fans, hood, ducts, air cleaners, and stacks. Local ventilation is designed to capture an emitted contaminant at or near its source, before the contaminant has a chance to disperse into the workplace air.

5.2 Analysis of ideas. 1: Local ventilation system

Industrial ventilation generally involves the use of supply and exhaust ventilation to control emission, exposures, and chemical hazards in the workplace. Traditionally, non-industrial ventilation systems commonly known as heating, ventilating, and air- conditioning (HVAC) systems were built to control temperature, humidity, and odours. (Local Exhaust Ventilation Publication, 2005:4)

Ventilation may be deficient in:

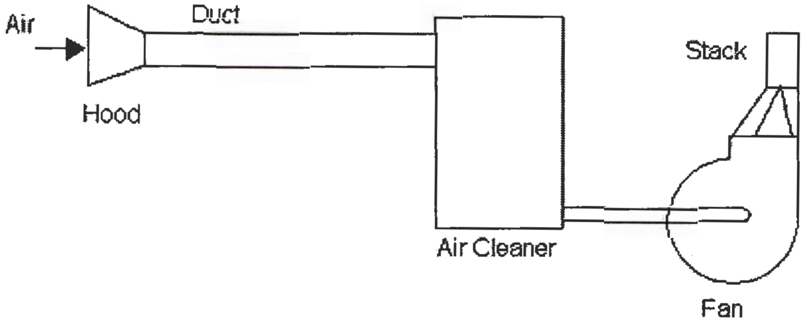
- Confined spaces.
- Facilities failing to provide adequate maintenance of ventilation equipment.
- Facilities operated to maximize energy conservation.
- Windowless areas. and
- Areas with high occupant densities.

Any ventilation deficiency must be verified by measurement.
There are five basic types of ventilation systems: (Local Exhaust Ventilation Publication, 2005:4):

- Dilution and removal by general exhaust;
- Local exhaust;
- Makeup air (or replacement);
- HVAC (primarily for comfort); and
- Recirculation system.

Figure 7 show a simple local exhaust system which might be used to extract dust from a workshop.

Figure 7: Components of a local exhaust system



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:2)

Ventilation systems generally involve a combination of these five types of systems. For example, a large local exhaust system may also serve as a dilution system, and the HVAC system may serve as a makeup air system.

The characteristics of the ventilation system that were documented during investigation of idea 1 included equipment operability, physical measurements of the system, and use practices. Before taking velocity or pressure measurements, researchers should note and record the operating status of the equipment. For example, are filters loaded or clean? Are variable –flow devices like dampers, variable-frequency drives, or inlet vanes in use? Are make-up units operating?

5.2.1 Measurements

Duct diameters are measured to calculate duct areas. Inside duct diameter is the most important measurement, but an outside measurement is often sufficient for a sheet metal duct. To measure the duct, the tape should be placed around the duct to obtain the duct circumference, and the number should be divided by (3.142) to obtain the diameter of the duct. Using the formula oc/3.142 = d, where oc stands for the outside circumference of the duct and d for the diameter.

5.2.2 Hood and duct dimensions can be estimated from plans, drawings, and specifications. Measurement can be made with a measuring tape. If a duct is constructed of 2.5 or 4 – 30cm sections, the sections can be counted (elbows and tees should be included in the length).

5.2.3 Hood – face velocities outside the hood or at the hood face can be estimated with velometers, smoke tubes and swinging vane anemometers, all of which are portable, reliable, and require no batteries.

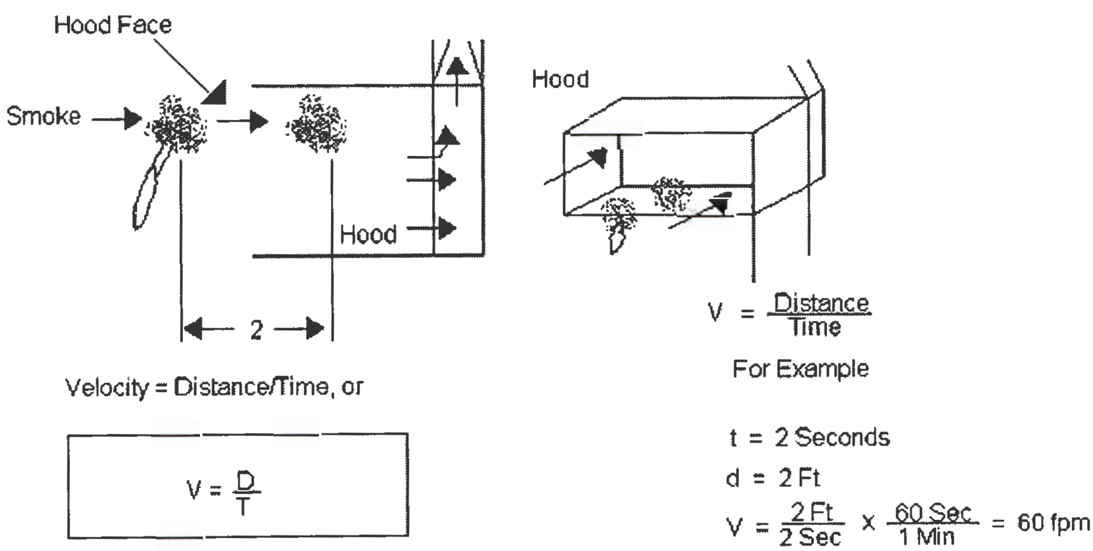
- The minimum velocity that can be read by an anemometer is 50 feet per minute (fpm). The anemometer should always be read in the upright position and only the tubing supplied with the equipment should be used.

- Anemometer often cannot be used if the duct contains dust or mist because air must actually pass through the instrument for it to work. The instrument requires periodic cleaning and calibration at least once per year. Hot – wire anemometers should no be used in airstreams containing aerosols to give heat so that aerosol can vaporise easily.

- Hood – face velocity measurement involves the following steps: Mark off imaginary areas, Measure velocity at centre of each area and average all measured velocities.

- Smoke is useful for measuring face velocity (see figure 8) because it is visible. Nothing convinces management and employees more quickly that the ventilation is not functioning properly than to show smoke drifting away from the hood, escaping the hood, or travelling into the worker's breathing zone. Smoke could be used to provide a rough estimate of face velocity:

Figure 8: Use of smoke to demonstrate air flow.



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:6)

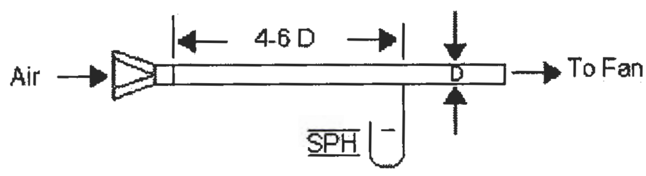
Direct and squeeze off a quick burst of smoke. Time the smoke plume's travel over a two- foot distance. Calculate the velocity in feet per minute.

For example, if it takes two seconds for the smoke to travel two feet, the velocity is 60 fpm.

This determines the distance of the hood from the dust emission point to effectively remove dust from the machine source.

5.2.4 Hood static pressures (SPH) should be measured about 4-6 duct diameters downstream in a straight section of the hood take-off duct. The measurement can be made with a pitot tube or by a static pressure tap into the duct sheet metal (see figure 9).

Figure 9: Use of static pressure tap into duct to measure hood static pressure.



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:7)

The use of a static pressure tap figure 9 is one of the basic testing equipment in hood design for a local exhaust system and it is important to note that :

a) Pressure gauges come in a number of varieties, the simplest being the U – Tube manometer.
b) Inclined manometers offer greater accuracy and greater sensitivity at low pressures than U- tube manometers. However, manometers

rarely can be used for velocities less than 800 fpm (i.e. velocity pressures less than 0.05"w.g.).

c) Aneroid- type manometer uses calibrated bellows to measure pressures. They are easy to read and portable but require regular calibration and maintenance to provide accurate results.

5.2.5 Hoods: The hood captures, contains, or receives contaminants generated at an emission source. The hood converts duct static pressure to velocity pressure and hood entry losses (e.g., slot and duct entry losses). Hood entry loss (H_e) is calculated according to the following equation:

$$H_e = (K)\ (VP) = /\ SP_h\ / = VP$$

Where: k = loss factor

Vp = velocity pressure in duct

I sph = absolute static pressure about 5 duct diameters down the duct from the hood.

(Occupational Safety & Health Administration(OSHA) Technical Manual 3:14)

A hood's ability to convert static pressure is given by the coefficient of entry (C_e), as follows:

$$C_e = \frac{Q\ ideal}{Q\ actual} = \sqrt{\frac{VP}{SP_h}} = \sqrt{\frac{1}{1+K}}$$

(Occupational Safety & Health Administration(OSHA) Technical Manual 3:15)

To minimize air –flow requirements the operation should be enclosed as much as possible, either with a ventilated enclosure, side baffles, or curtains. This helps both to contain the material and to minimize the effect of room air currents.

5.2.6. Duct velocity measurements may be made directly (with velometers and anemometers or indirectly (with manometers and pitot tubes) using duct velocity pressure.

1. Air flow in industrial ventilation ducts is almost always turbulent, with a small, non - moving boundary layer at the surface of the duct.
2. Because velocity varies with distance from the edge of the duct, a single measurement may not be sufficient. However, if the measure is taken in a straight length of round duct 4 –6 diameters downstream and 2 –3 diameters upstream from obstructions or directional change (then the average velocity pressure is about 81% of centreline velocity pressure).
3. A more accurate method is the transverse method, which involves taking six or ten measurements on each of two or three passes across the duct, 90° or 60 opposed. Measurements are made in the centre of concentric circles of equal area.
4. Density corrections (e.g., temperature) for instrument use should be made in accordance with the manufacturer's instrument instruction manual and calculation / correction formulas.

5.2.7 Air cleaner and fan condition. Measurements can be made with a pitot tube and manometer. To choose the proper fan for a ventilation system, this information must be known:

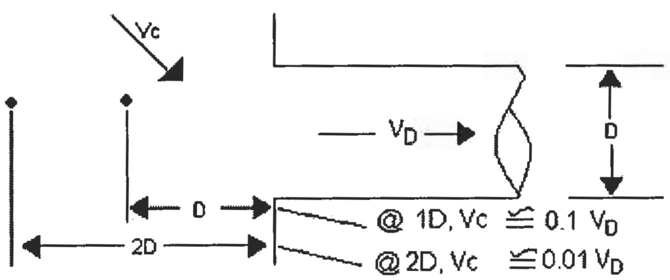
- Air volume to be moved;

- Fan static pressure;
- Type and concentration of contaminants in the air (because this affects fan type and materials of construction) ; and
- The importance of noise as a limiting factor.

5.3 Good practices

Figures 10, 11 and 12 illustrate how hood placement must be close to the emission source to be effective. Maximum distance from the emission source should not exceed 1.5 duct diameters.

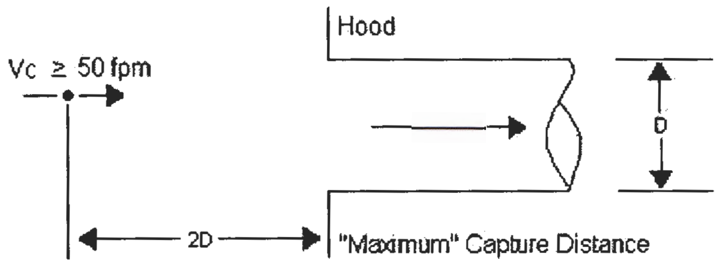
Figure 10: Relationship of capture velocity (v_c) to duct velocity (V_d)



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:8)

Figure 10 shows the approximate relationship of capture velocity (v_c) to duct velocity (v_d) simple plain or narrow flanged hood is illustrated in figure 10. For example, if an emission source is one duct diameter in front of the hood and the duct velocity (V_d) = 3.00 feet per minute (fpm), then the expected capture velocity (V_c) is 300 fpm. At two duct diameters from the hood opening, capture velocity decreases by a factor of 10, to every 30 fpm.

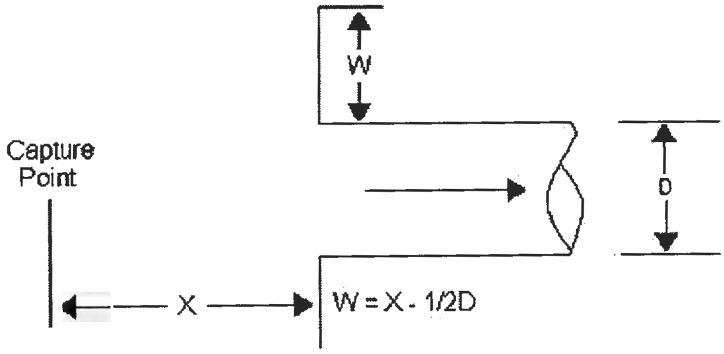
Figure 11: The rule of thumb for simple capture hoods is that the maximum capture distance should not be more than 1.5 times the duct diameter.



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:8)

Figure11 shows a rule of thumb that can be used with simple capture hoods. If the duct diameter (D) is 6 inches, then the maximum distance of the emission source from the hood should not exceed 9in. Similarly, the minimum capture velocity should not be less than 50 fpm.

Figure12: Effective flange width (w)



(Occupational Safety & Health Administration(OSHA) Technical Manual 3:8)

Figure12 provides a guide for determining an effective flange width. When using a capture or receiving hood, the hood should be located as close to the contaminant source as possible. Reducing the amount of contaminants generated or released from the process reduces ventilation requirements. The hood should be designed to achieve good air distribution into the hood opening so that all the air drawn into the hood helps to control contaminants.

The purpose of most ventilation systems is to prevent worker inhalation of contaminants. For this reason, the hood should be located so that contaminants are not drawn through the worker's breathing zone. This is especially important where workers lean over an operation such as an open – surface tank or welding bench. Hoods must meet the design criteria in the ACGIH Ventilation Manual or applicable OSHA standards. Most hood design recommendations account for cross-drafts that interfere with hood operation. Strong cross-drafts can easily reduce a hood's effectiveness by 70%. (OSHA) Technical Manual 3:15). Standard hood designs may not be adequate to contain highly toxic materials. The hood should be designed to cause minimum interference with the performance of work. Positioning access doors inside an enclosure that must be opened and closed often means that in practice the door will be left open, and locating capture hoods too close to the process for the worker's convenience often means that the hood will be disassembled and removed. Hoods should never increase the likelihood of mechanical injury by interfering with a worker's freedom to move around machinery.

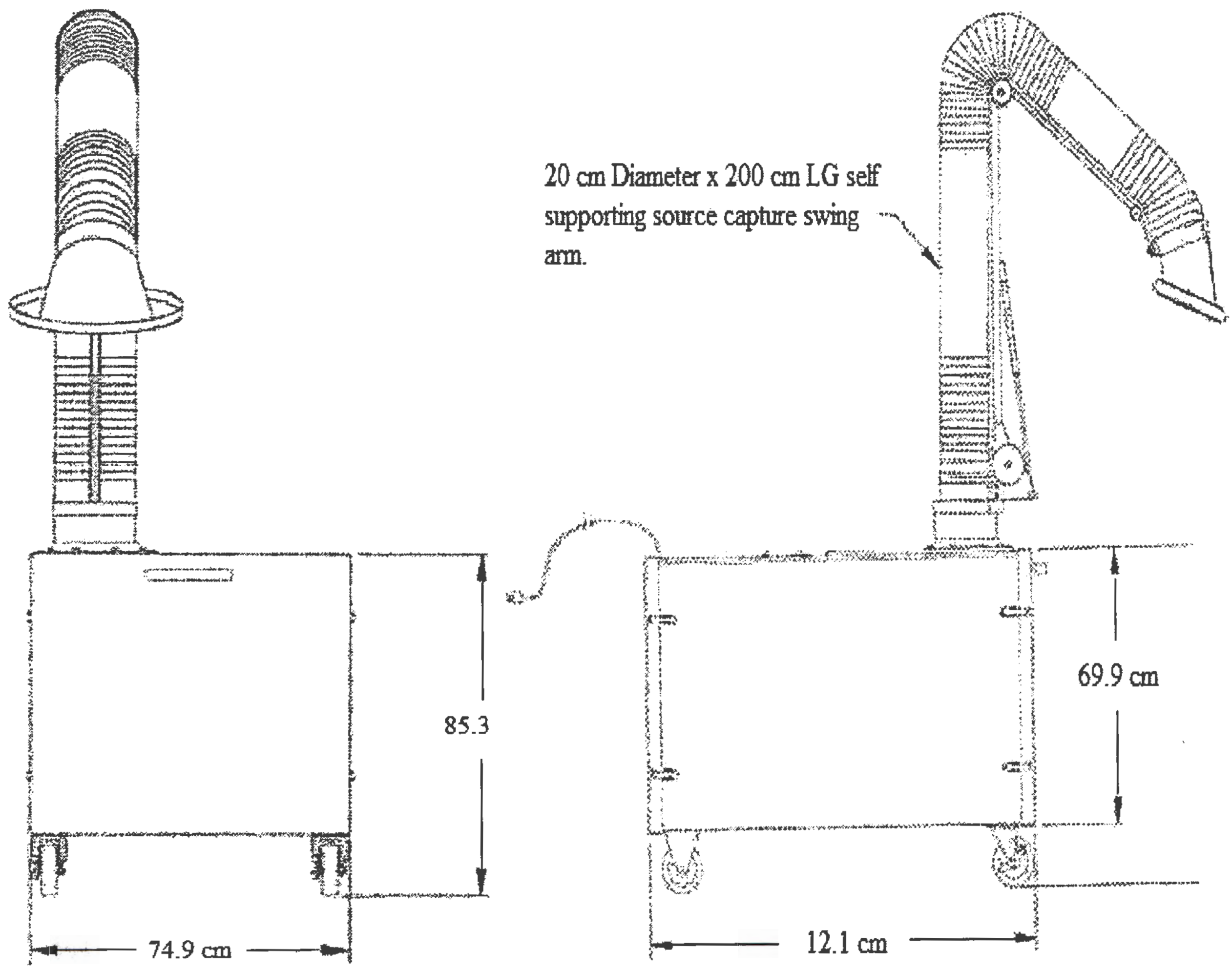
Two common misconceptions about hoods that are a part of local exhaust systems are:

- Hoods draw air from a significant distance a far from the hood opening, and therefore they can control contaminants released some distance away. It is easy to confuse a fan's ability to blow a jet of air with its ability to draw air into a hood. Hoods must be close to the source of contaminant(s) to be effective.
- Heavier than air vapour tends to settle on the workroom floor and therefore can be collected by hood located there. A small amount of contaminant in the air (1,000 ppm means 1,000 parts of contaminant plus 999, 000 parts of air) has a resulting density close to that of air, and random air currents will disperse the material throughout the room (ACGIH Ventilation Manual, 2004:2).

5.4 Analysis of ideas. 2: Mobile Flexvac

This is a mobile Flexvac direct source dust extraction machine design. It has a built in extraction system to capture contaminants. This has a flex extraction pipe to capture wood dust at the source. The flex pipe's size and reach allows it to extract dust as it is adjustable to meet needs. The mobility of the machine is ensured by four castor wheels, of which two are lockable. The suction can be bent, twisted and turned into virtually any position and will remain in place until repositioned.

Figure 13: Front and end views of the mobile flex vac machine



(Tool Post Dust ExtractionTechnical Manual 2003: 3)

All the flex components are made from shatterproof and chemically resistant polypropylene. It has flame retardant characteristics, resists abrasion and withstands temperatures from -13 to 180 degrees F. The support column is made from powder coated steel. The base platform consists of solid 1.25"PVC plates. The flex system can be used to capture contaminants generated by processes in a wide variety of application and environments such as Laboratory, Hospitals, Clean rooms, Assembly and Finishing, Soldering/ Electronics where fume contaminants are produced.

5.5 Analysis of ideas 3: The canvas dust extractors cleaning machines

The filtration provided by this unit is achieved through three stages of filtration, achieving the removal of particles down to 0.5 microns. (Most of the "old" Dust Extractors about 5 microns in size: it is the particles which fall into the 1 micron to 5 micron range that do most damage to human tissue and organs. Hence, in recalculating these particles, the Chip extractor-style of unit actively damages the user's health, NOT protecting it at all!). The handling capability of these units is that the fan is located after the filtration stage and the extracted contaminants before it reaches the collection sack. This arrangement also ensures that all of the dust containing parts of the system is under vacuum the whole time so that there is no danger of leakage of dust back into the workshop atmosphere.

Figure14: MC 100 Bench or wall mounted unit (Health and safety/ Dust Extraction / CamVac).

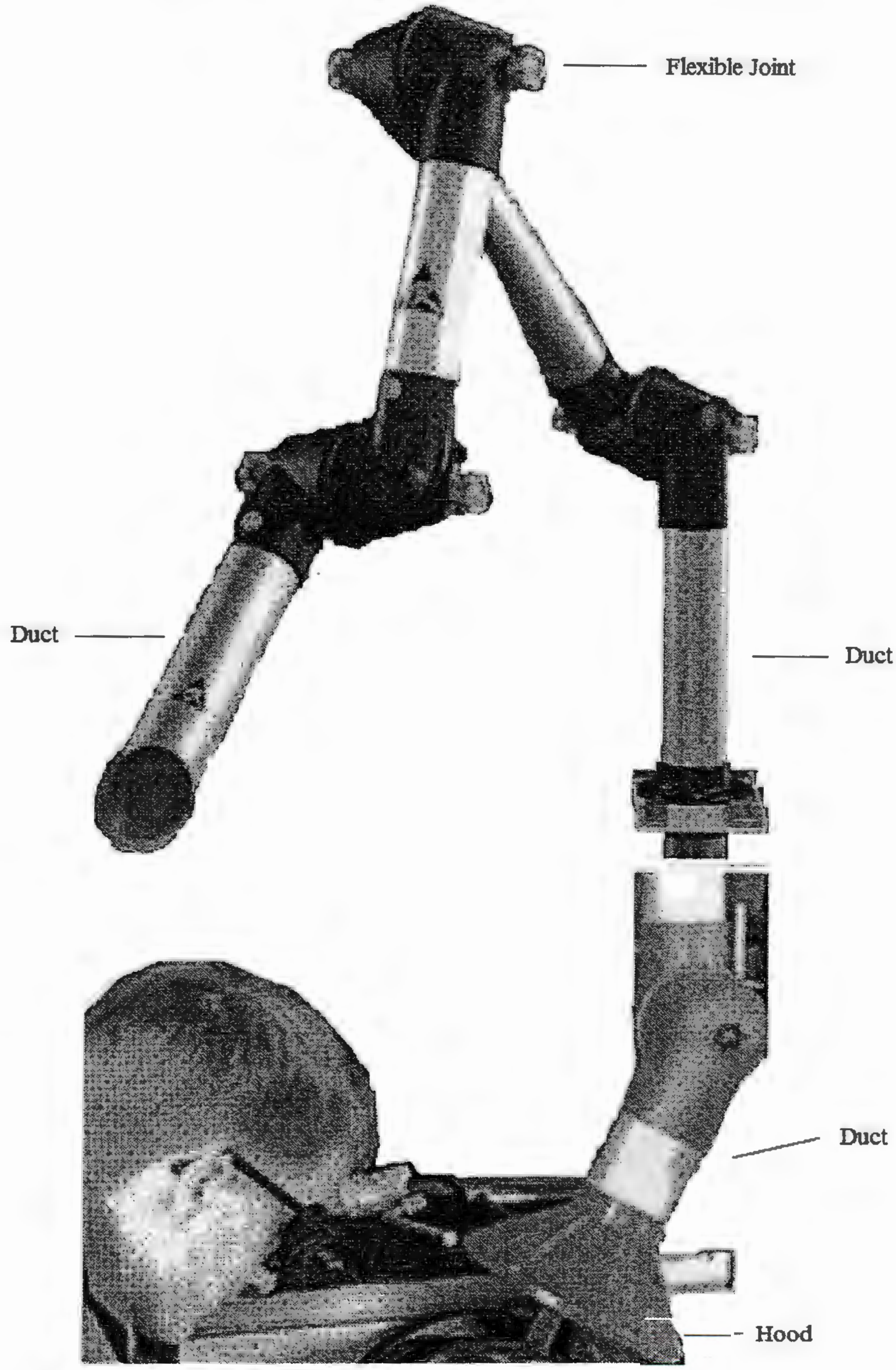
(Tool Post Dust ExtractionTechnical Manual 2003: 1)

The Camvac machine Figure 14. GW286 is conveniently wall-mounted, as illustrated, and will ably cope with the needs of the average small workshop. This can be used to provide extraction to lathe, band saw and sander. This unit operates from a 220 volt single phase AC supply with a standard three-pin plug.

5.6 Analysis of ideas 4: Precision dust extraction system

The system manufacture of precision dust extractors for local exhaust often requires individual fume extraction systems for the protection of workers.

Figure 15: Precision dust extraction system



(Tool Post Dust ExtractionTechnical Manual,2003:3)

Typical uses

Figure15 illustrates the typical uses of dust extraction on the workplace in a manufacturing workshop. The electro engineering, electronics, mechanical engineering, laser technology, chemical medical, pharmaceutical, and foodstuff industries, as well as laboratories, hospitals, schools, and universities are typical users of the exhaust process system. Extraction using an exhaust arm; an exhaust arm extraction system can be used for any work station where harmful substances are presented in dangerous concentrations. An exhaust arm was originally developed for soldering benches, but can now be used for many other purposes. The system is designed to remove gases, smoke fumes, smells, and dust particles with utmost safety. In order to minimize noise emission and pressure loss, the exhaust arm is designed so that only the acid – proof threaded sleeves and springs are located inside. Otherwise, it is self-supporting and can be adjusted to suit the situation.

5.7 Evaluation of ideas

5.7.1 Dust extraction

With our ever increasing awareness of Health and Safety in the workshop, and of the true extent of dust hazards, especially in regard to woodturning and wood machining, the need for effective and efficient workshop dust extraction has never been so urgent. In truth, most of the devices offered as "Dust Extractors" are in fact "Dust Re-Circulation Machines" expelling back into the workshop atmosphere the fine dust particle most likely to do damage to the respiratory system or to act as carcinogens to learners and staff users of the workshop(Tool Post Dust ExtractionTechnical Manual: 3). They may be capable of removing chips and shavings, but they cannot filter out the damaging fine dusts – the true causes of most of the respiratory, dermatological and carcinogenic problems that can result from working wood without adequate protection (Hemsley. The tool post dust extraction 2003:2)

The researcher suggests the adoption of a three – point strategy to minimize workshop dust hazards. Working from the operator "outwards", personal respiratory protection is undoubtedly important and equipment to deal with this is covered in the "Respirator" section. The respirator could be considered as the last bastion of defence: the very air that will enter your lungs is filtered at the point of entry into your body. But it might also be said that prevention is better than cure; if we can reduce that amount of dust getting into the atmosphere, then we can reduce the load imposed on the respirator. The best way to do this is to extract the dust, along with the chippings, at the moment it is created. Removing particles down to 0-0.5-microclene range.

The information of the analysis of ideas gives an outline of the solution to the dust problem, which should include:- Method of dust capture, Type and position of dust collector, method of collection of dust for disposal, any health and safety issues and installation requirements, and easy to operate hoods attachments. Operating and maintaining the arm must be easy. It should be adjusted to a new position with just one hand and dismantled for cleaning without the need for tools.

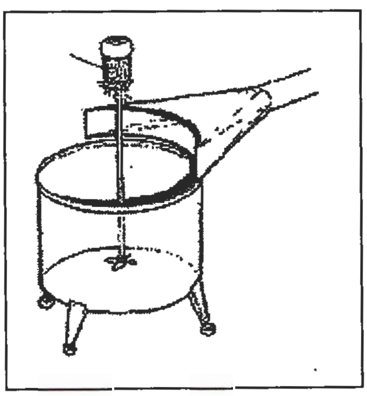
5.7.2 Dust capture method

From observations of the application, the dust capture method must be a suitable system to solve the dust problem The solution should utilize the minimum amount of 'control air' possible to achieve a good level of dust control, as in general the costs involved are directly related to the quantity of control air employed. The solution may take the form of the provision of localized hoods at each dust generation point or the use of an enclosure around a number of these points. In some cases a combination of these two methods can be considered the best solution.

Local proximity hoods.

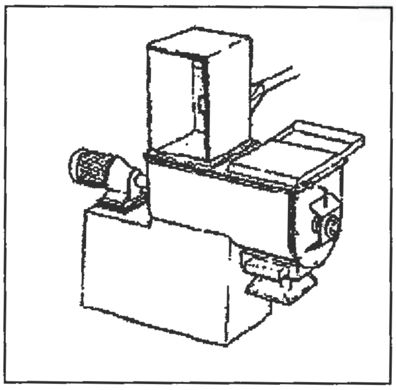
Figures 16a and 16b show types of local proximity hoods applied to drum filling operation.

Fig.16a Local proximity Hood



(Occupational Safety & Health Administration(OSHA) Technical Manual,1992:3:10)

Fig.16b Enclosure hood



(OccupationalSafety&HealthAdministration(OSHA) Technical Manual,1992 :3:10)

The use of local proximity hood applied to drum filling operation is shown in fig.16a. This hood is designed to pull a curtain of air over the top of the drum to capture the dust created while materials are being tipped into the drum. The hood is shaped around the periphery of the drum to ensure that the hood face is as close as possible to any possible point of dust escape, as the effectiveness of an open face hood diminishes rapidly as the distance from it increases. A simple formula for calculating the quantity of air (Q) M^3 / min required to provide a capture velocity (V) M / min for a dust a varying distance (X) M from an open hood of area (A) m^2 is:

$$Q = V\ (10X^2 + A)$$

The use of an enclosure to control the dust created when loading a mixer is shown in fig.16b. In using an enclosure, the dust control engineer is seeking to contain all the dust created by providing a controlling air velocity of typically 1m/sec across the open face of the enclosure through which the materials are being loaded. This is very effective method of removing dust as an enclosure eliminates the possibility of cross draughts that can be detrimental to the effectiveness of local proximity hooding.

The determination of the appropriate capture velocity is critical for each application if effective control is to be achieved. This can range from around 0.3 m / sec for applications such as the capture of evaporation fumes from a tank in a draught free area up to 10m / sec for capturing dust from applications such as grinding or Abrasive blasting. The ranges of capture velocities are given in Table 12.

Table 12: Range of capture velocities.

Method of generation	Capture Velocity (m/sec)	Typical processes
Released without Noticeable movement	0.3 - 0.5	Evaporation of vapours, free jet show blast room, thermal spray booth, welding fumes, fine sanding dust
Released with low velocity	0.5 - 1.0	Powder coating booth, weighing, packaging, low speed conveyor transfer points, oxy and laser cutting table (0.75- 1 m/s)
Active generation	1.0 – 2.5	Plasma cutting table (1.0 – 1.25 m/s), shake out, high speed conveyor belt
Released with great force	2.5-10	Grinding

(OccupationalSafety&HealthAdministration(OSHA) Technical Manual,1992 :3:16)

The need for access to the process both in normal operation and for cleaning and maintenance should be taken into account. There usually needs to be some compromise between providing the very best design for achieving effective control and the requirements of the operator and / or process. Consideration should also be given to how draught can be either eliminated or reduced as the amount of air that has to be used to capture the dust increases significantly in the presence of cross draughts.

The open face of an enclosure can often be reduced by the use of some form of either rigid or flexible sheeting which will reduce the quantity of control air needed and consequently reduce total costs. Care must be taken, however to ensure that any reduction does not impede the operations inside the enclosure.

5.7.3. Ducting system

The design of the ducting system connecting the extraction point to the dust collector is a very important factor in the creation of a successful installation. The system design should take into account:-

- The type, nature and quantity of dust to be handled;
- The likelihood of internal wear from abrasion;
- The appropriate conveying velocity for the dust concerned to avoid either excessive power consumption and excessive wear or settlement in the duct (see table 13);
- The need for inspection and cleaning;

Table 13: Range of conveying velocities for different types of dusts

Material Conveyed	Conveying Velocity in ducts m/sec
Vapour, gases, fumes, very fine dusts	7.6 – 10.2
Fine dry dusts	15-18
Average industrial dusts	18 –20
Coarse particles	18 –23
Large particles	23 and higher

(Occupational Safety & Health Administration(OSHA) Technical Manual, 1992 : 3:18)

The ducting construction should be of sufficient strength and thickness for the proper application, is dust tight and adequately supported. The ducting system should also be properly balanced by means of internal balancing cones if at all possible, or fixable dampers to ensure that the correct quantity of control air is extracted from each point. An unbalanced system will provide more air than is required at some points, usually the smaller ones, whilst starving others and therefore providing inadequate extraction. Internal balancing cones are the preferred method as once they are set they give consistent and reliable results. Dampers are often moved by operators throwing the system out of balance and they can be a source of material build up inside the duct.

5.7.4. Dust collectors

There are a number of different types of equipment that can be used to separate the entrained dust from the conveying airflow. The most common are listed below outlining their strengths, weaknesses and variations to be considered:

- Cyclones
- Bins

The use of cyclones to provide separation of the entrained dust from the control air is the traditional and the most basic approach.

5.7.5 Drum sander.

This machine consists of a rotating drum covered with an abrasive material at which sanding is carried out. The abrasive drum is sometimes replaced by a brush. Captor hoods positioned behind the drum can be inefficient if they are not positioned close enough to the sanding operation.

Figures !7a and 17b show types of exhaust hoods for drum/bobbin sanders.

Figure 17: Exhaust hoods for drum/bobbin sanders.

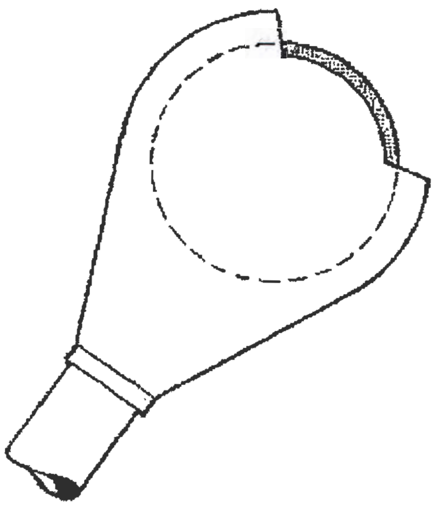


Fig.17a.

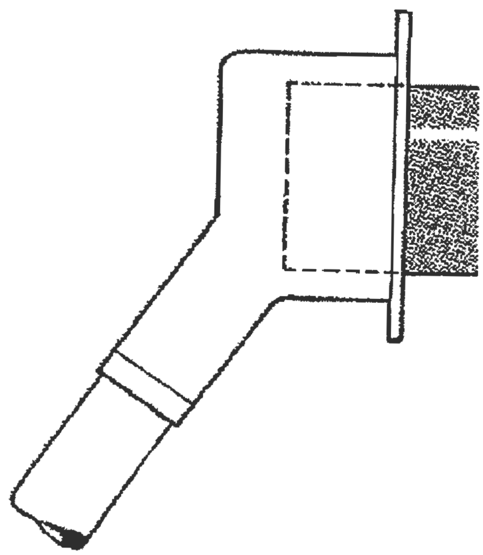


Fig.17b.

(Occupational Safety & Health Administration(OSHA) Technical Manual 1992 : 3:17)

Figure 17a show a captor hood which more fully encloses the sanding drum, giving more effective control. Flanged inlet openings will considerably improve extraction efficiency (see Figure 17b).

5.7.6. Design specifications

The design specification provide parameters for which the structure should meet to satisfy the requirements of the intended user.

- Good structure: The mechanical structure should be simple to understand. The electronics and mechanism structure should be a good example of a clean modern system.

- User friendly: The system should be small and easy to operate on the wall next to the machines, ensuring an optimal extraction.
- Good robustness and simple maintenance: The system must be easily maintained by learners working on the machine.

Ensure proper capture velocity is produced at each local exhaust hood. Design vacuum systems to reach within 12.7 mm (1/2 inch) of the contaminant source. Design the pickup air – stream to have a velocity of two to three times the generation velocity for particle sizes from 20 to 30 micrometer (20 to 30 micron).Design for an additional velocity of: (1) four to five times the generation velocity to pull the particles up through 300 U.S. Standard mesh, or (2) six to eight times the generation velocity to pull the particles up through a 20 U.S. standard mesh. Design the vacuum system duct to balance with the exhaust system duct where the two systems connect.

Hood Design: Provide a hood for each operation that produces dust. This includes sawing shaping, planning, and sanding operations. Design and position all hoods so the wood dust will fall, be projected, or be drawn into the hood in the direction of the airflow. Construct hoods of non-combustible materials. Ensure the hoods do not interfere with worker operations. In some cases, the exhaust hood should be utilized as a safety guard to meet the specific equipment and process requirements.

5.8: Wall mounted extractor (chosen idea)

This wall mounted extractor removes dust from the workplace and ensures that all of the dust containing parts of the system are under vacuum the whole time so that there is no danger of leakages of particulates back into the workshop atmosphere.

Figure 18: Wall mounted extractor.

(Tool Post Dust ExtractionTechnical Manual 1992 :1)

Figure18 shows the chosen wood dust extractor which can be conveniently wall- mounted, to ably cope with the needs of the average school workshop. The system is suitable to solve the dust problem. The solution would utilize the minimum amount of 'control air' possible to achieve a good level of dust control as, in general, costs involved are directly related to the quantity of control air employed. This could be used to provide extraction from lathe, band saw and sander during manufacturing in the workshop.

5.9 Summary

The ideas analyzed in this chapter provided the scope for the development of design idea 3 of a dust extraction system. Dust extractors use suction to effectively capture chips, wood dust, metal shaving, plastic grinding and debris and eliminate harmful contaminants so as not to irritate lungs. Many dust extractors are bulky and can not be moved easily around a workstation with ease. The system designed in this study was small and easy to operate on the wall next to the machines, ensuring optimal extraction. This keeps dust away from whichever project was being worked on while not interrupting or affecting other learners in the workshop.

CHAPTER 6

MODEL OF DUST EXTRACTION SYSTEM

6.1 Introduction

Completing the project required a number of skills, most of which depended on personal experience, knowledge, and ability to look ahead and make calculated judgments about the production process to complete the task. The making stages of the system and then the process of manufacture are elaborated in this chapter. The materials, realization method stools and machinery are factors that led to the development of the production plan so that the manufacturing processes are considered carefully. The production plan provided a sequential execution of the manufacturing processes involved.

6.2 Design procedure.

Exhaust System Design Procedure for system design calculations.

The following are design and installation procedures for all industrial ventilation systems.

Design all industrial ventilation systems in accordance with specifications. Identify all significant contaminant sources that require ventilation control. Provide a source characterization with area diagrams of the contaminant sources, and learners work areas. Also consider how the system being designed might affect the performance of any existing processes, industrial ventilation systems or HVAC systems. Consider how the facility is to be used or expanded in the future. It may be possible to initially specify fans that are capable of handling future needs at minimal cost.

Select or design the exhaust hood that best suits the work piece or operation. Design the exhaust hood to close the work piece or operation as much as possible. This will reduce the ventilation rates and require providing contaminant control. This UFC provides optimum exhaust hood designs for many of the operations covered. Determine the capture velocity required to control generated contaminants. Capture velocities in this UFC are specified assuming there are no cross drafts or turbulences that adversely affect the capture efficiency. Reduce potential for cross drafts or turbulence near a given exhaust hood by proper locating and signing the hood with baffles, and also by designing the replacement air system to complement the exhaust system. Design the exhaust air system to generate a minimum capture velocity of 0.762 m/s (150 fmp) to capture all the contaminants at the source (0.762m/s is the minimum capture velocity, because of the size of the workshop machines which are in the light industrial machines category).

Determine the exhaust volumetric flow, in cubic meters per second (m^3/ s) [cubic meters per second], required to maintain the capture velocity determined. Create a line drawing of the proposed system. Include plan and elevation dimensions, fan location and air cleaning device location. Identify each hood, branch duct and main duct sections.

Size ductwork using the balance by design or the blast gate method. Maintain the required minimum transport velocity throughout the system. Specify duct gauge, reinforcement schedule and hanger design and spacing in accordance with standard specifications.

Determine requirements for replacement air. Based on the process, determine if the room should be under slightly negative, neutral or slightly positive pressure with respect to the surrounding area. The surrounding area can be either outside the building envelope or an adjacent room or hallway. Determine if tempered replacement air is needed. Provide a hood for each operation that produces dust. This includes sawing shaping, planing, and sanding operations. Design and position all hoods so that the wood dust will fall, be projected, or be drawn into the hood in the direction of the airflow. Construct hoods of non-combustible materials. Ensure the hoods do not interfere with work operations. In some cases, the exhaust hood may be utilized as a safety guard. Prepare all the materials needed and cut them to the specified dimensions accurately. This will make the fitting of the other parts to fit accurately and with no misalignments when assembling the project.

6.3. Fan

When selecting fan capacity, consider if the process room pressure will be positive, negative or neutral with respect to the external areas. Select a fan that will provide the necessary volumetric flow rate to maintain the desired process room pressure. Ensure that all sources of exhaust air are considered when selecting fan capacity. See paragraph 2 – 4.5 for more details. Specify fan shafts that have a uniform diameter along the entire length. Use bearings that are rated with an average life of 200.00 hours. This reduces the frequency of replacing the bearings. The bearings will last for a long time if proper routine lubrication of the bearing is done. Select only energy efficient motors. Select the motor to handle cold start-up amperage for non-standard air processes. Specify vibration – isolating couplings at the fan inlet and outlet. Mount all fans on vibration isolating bases.

6.4 Development of chosen idea (wall mounted extractor)

The filtration provided by this wall mounted extractor figure 18 is achieved through three stages of filtration achieving the removal of particles down to 0.5 microns.

Figure 18: Wall mounted extractor.

(Tool Post Dust ExtractionTechnical Manual, 2003 : 3)

Figure 18 shows the chosen wood dust extractor which can be conveniently wall- mounted, to ably cope with the needs of the average school workshop. This can be used to provide extraction from lathe, band saw and sander.

6.5 Exhaust system design specifications development.

The specifications provide the knowledge and skills necessary to effectively design and develop commercial and industrial exhaust systems, in accordance with all relevant standards, codes and authorities such as Health and safety, Wood dust, Noise, Smoke, and Fire Hazard identification. The systems types and duct design respectively such as applications, application flow chart, system requirements, hazard identification, effluent types and removal, relation with smoke spill systems, supply air dilution applications, natural ventilation applications, fan assisted exhaust applications, replenishment of exhaust air, system components, static, velocity, total pressure, pressure drop, Fouling, Transitions, elbows, fan position and mounting, noise and noise attenuation, requirements for access and maintenance and system integrity as these determine the efficiency.

Fan and Motor

The efficiency of any exhaust system depend on the fan and motor selection specifications which are applications, suitable fan types, motor rating and suitability, balancing the fan duct system and flame proofing.

Filters and filter

Filters and filter section are: types and application and capture velocity. The outlet design location: prevailing winds, position relative to air intakes and weather and bird proofing. The cycling /operation control are: applications, code / regulation requirements, monitoring of contaminants, contaminant detection, sensors, variable speed fan and flame proofing of control equipment.

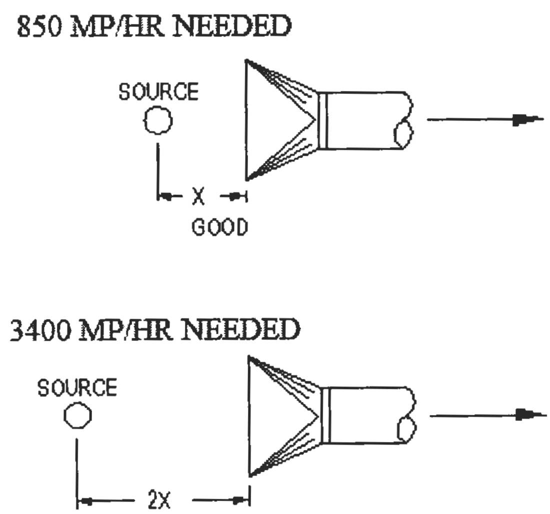
Outlet design location

An efficient installation begins with the control of dust at its source with the precise design of the entrainment hood. In all plants and workshops, the position of the hood in relation to the dust and fume source dictates the extraction rate.

6.6 Dust extraction system

In dust extraction systems, every effort should be made to ensure the hood is sited in such a position that the natural throw of the material is in the direction of the hood. By making use of this natural assistance, the extraction rate of the system that is required to entrain the dust into the duct work can be kept low. By incorporating the captive velocity as close to the dust emission as possible, the initial capital installation, and the subsequent running costs are kept to the minimum. The hood distance positions from the source of contaminants are given below in figure 19.

Figure 19: Hood extraction positions.

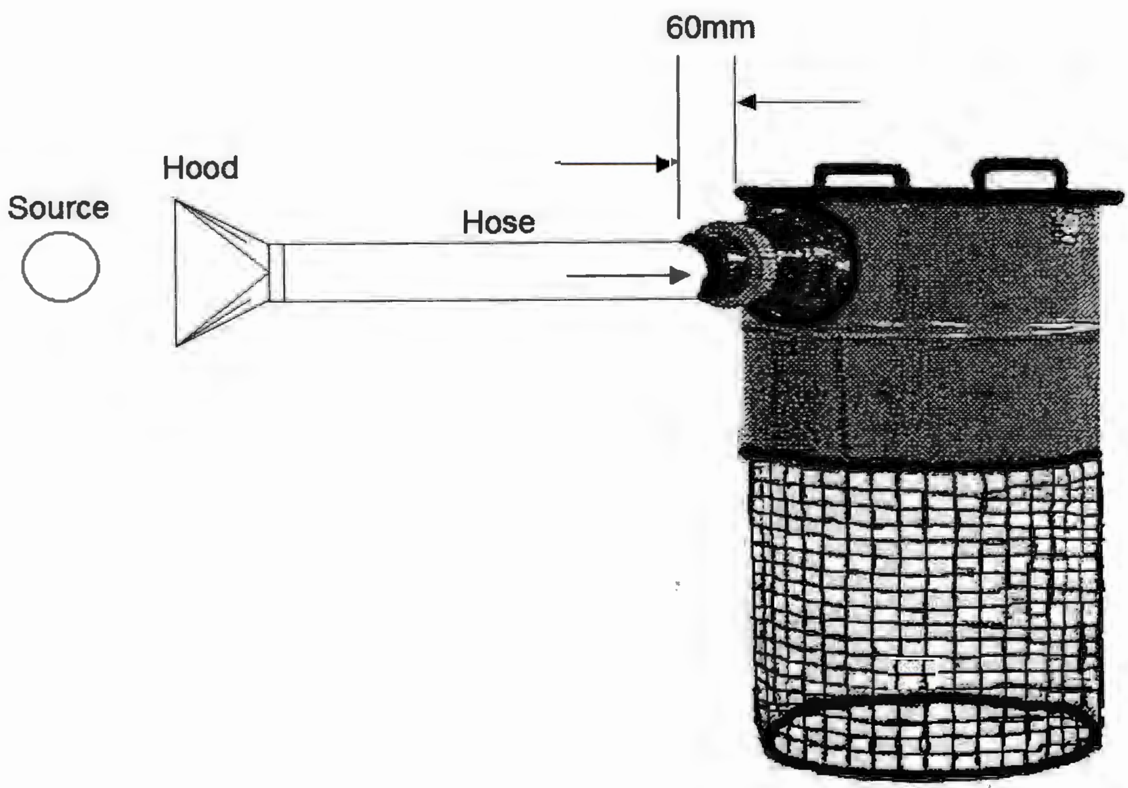


(Mac Adams, 2001:3)

For a given hood shape, the tendency is for air to be drawn equally from all directions. The velocity drops rapidly as the distances from the hood increases. Figure 19 illustrate the velocities obtained, with the distances expressed, where x stands for hood diameter. It is evident that a hood cannot control dust particles at any distance from the hood mouth. A flanged hood will control dust, using an air volume of approximately 30% less than would be required for.

The fully flexible hose assembly can be positioned into virtually any shape and it will hold that position firmly. The hose is terminated in an inlet funnel and extension sections are also available. The hose fits directly into the 60 mm inlet of an extractor or it can be connected into a ducting system as shown here in figure 20.

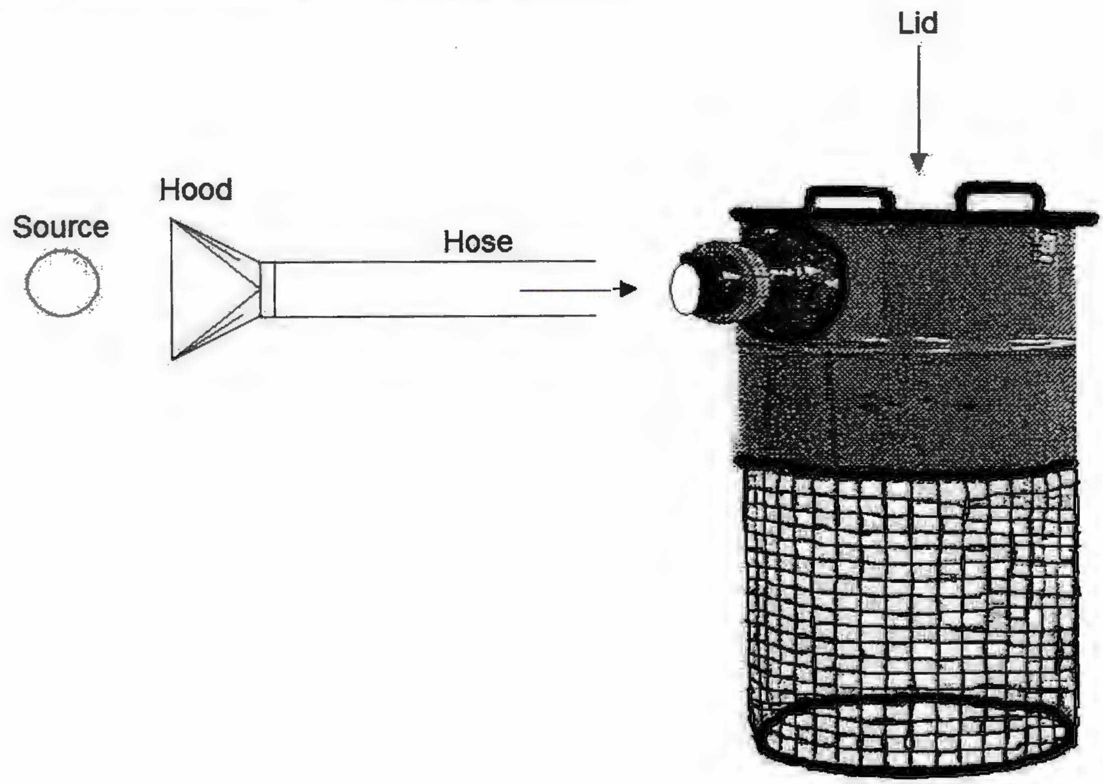
Figure 20: Inlet hose to extractor



(Tool Post Dust ExtractionTechnical Manual, 2003 : 4)

The system is suitable to solve the dust problem. The solution should utilize the minimum amount of 'control air' possible to achieve a good level of dust control as, in general, costs involved are directly related to the quantity of control air employed. The development drawings below (figure21) show the solution in the form of localized hoods at each dust generating point.

Figure 21: Assembly of parts of the extractor

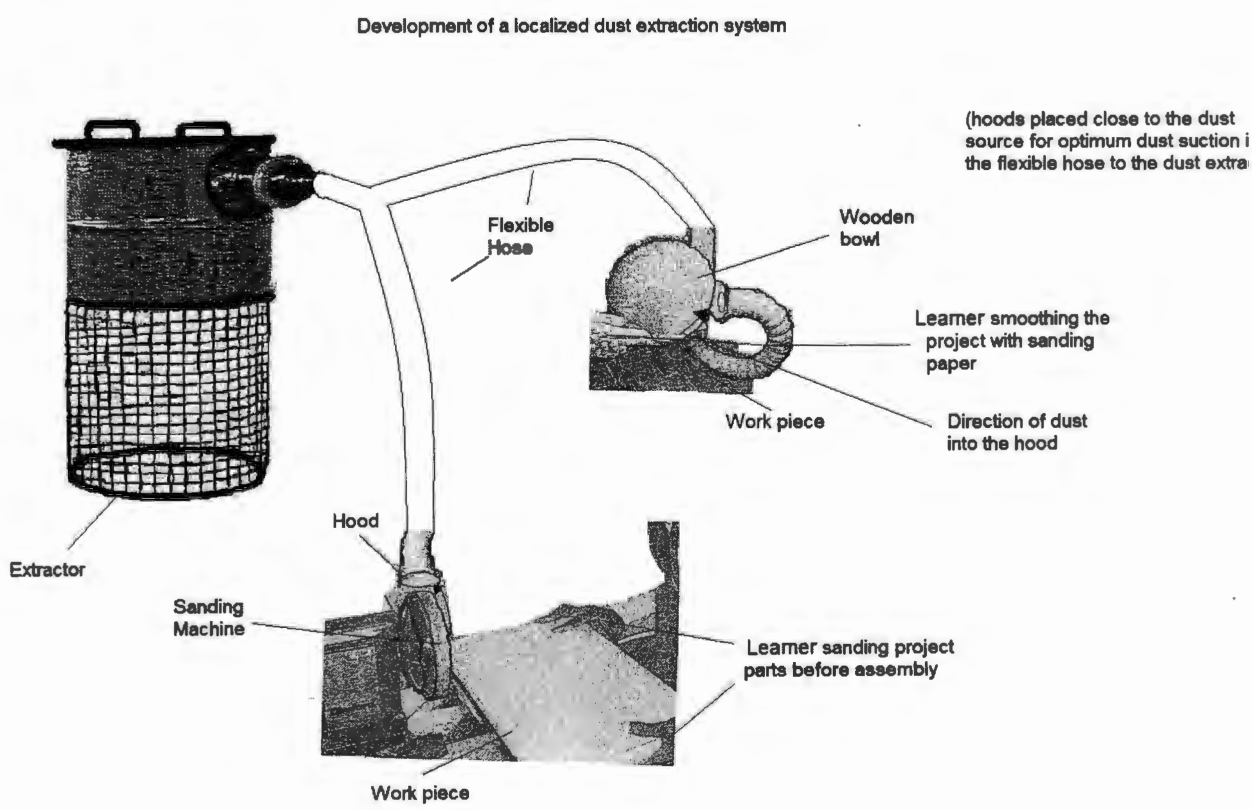


(Tool Post Dust ExtractionTechnical Manual, 2003 : 5)

The extractor contains a wire mesh support for the poly bag and a curious 25cm pipe ,to 'balance air flow', it has no outlet it is a means of stabilizing the pressure difference outside and inside the poly bag the lid holds the motor hence a pretty weight. There are two holes cut in it. The lid serves the motor; any dust coming through the inlet is filtered by the cloth filter.

The seal lid, to the tub, is rubber grommet which sits on top of the cloth filter (elasticated waistband sewn onto the cloth) which sits on top of the poly bag. The top of the device is clearly dual used having one hole occupied with a motor-over which the paper filter is sealed; again with a rubber band, the second hole exists for the extractor. Figure 22 show a localised dust extraction system applicable in the for removal of dust in the workshop.

Figure 22: Localized dust extraction system.



(Tool Post Dust ExtractionTechnical Manual, 2003 : 6)

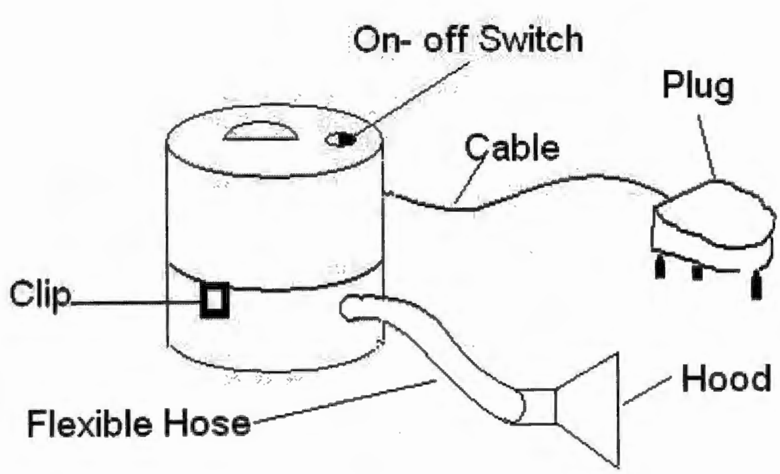
The solution took the form of the provision of localized hoods at each dust generation point. The hood is placed at a distance which ensures good dust removal from the point of emission. The arrows on the machine(figure

22) show the direction of dust sucked into the hood to the dust extractor. This leaves the learner clean and safe as all the dust produced during the sanding process is removed.

6.7 Model realization of dust extractor

The model operates on a 12 volt direct current. The motor capacity is 12volts. This model has an inlet. The motor is attached to the lid covered with a clear filter to protect the motor from dust. It has an off and on button on the top with clips to clip the lid motor to the dust collector. Figure 23 shows assembly of the dust extractor.

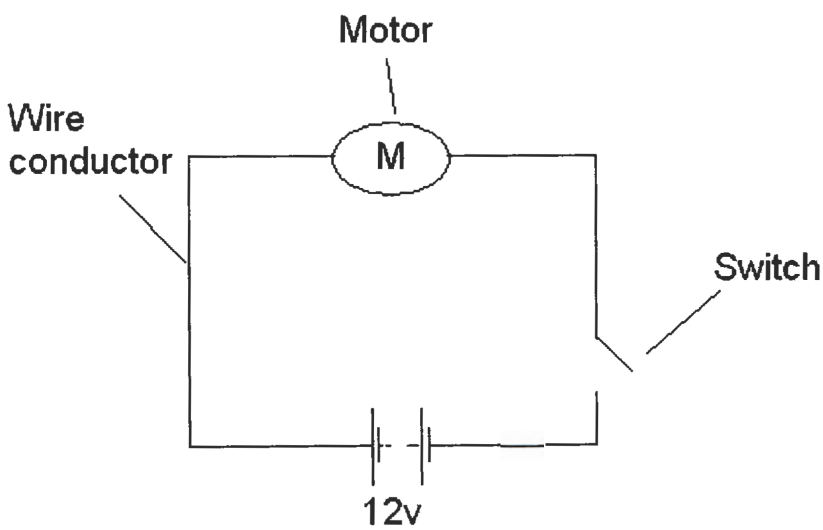
Figure 23: Assembly of dust extractor.



(Tool Post Dust ExtractionTechnical Manual, 2003 : 7)

Figure 23 shows the assembled dust extractor, the electricity cable and plug, the flexible hose and hood connected. For maximum suction secure the top section of the unit with all 3 clips. The electrical connections required for the operations of the dust extractor are shown in figure 24.

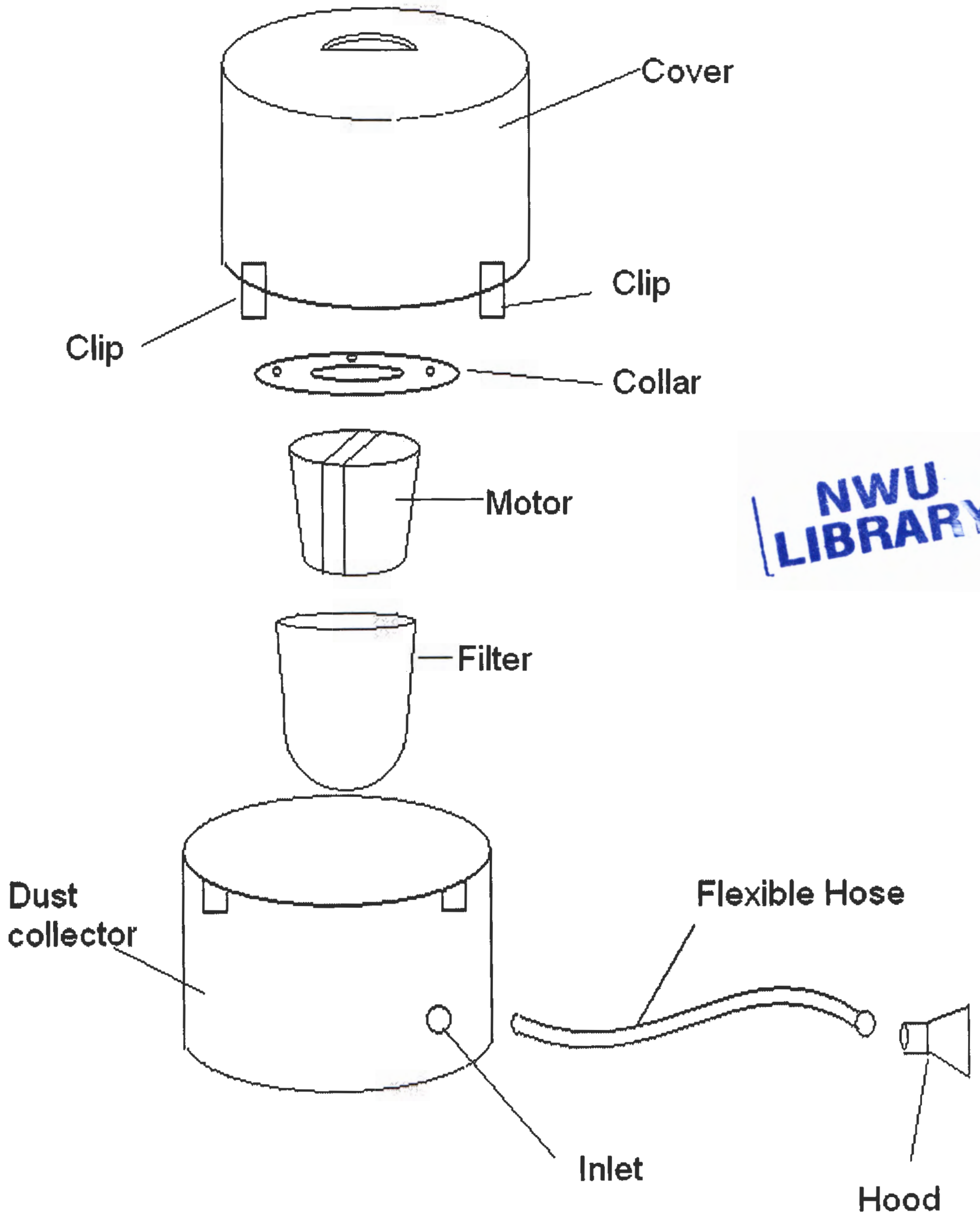
Figure 24: Circuit diagram of a dust extractor.



The electrical circuit (fig 24)shows the electrical parts and connection of the dust extractor.

Figure 25 shows an exploded view of the dust extractor.

Figure 25: Exploded view of dust extractor.

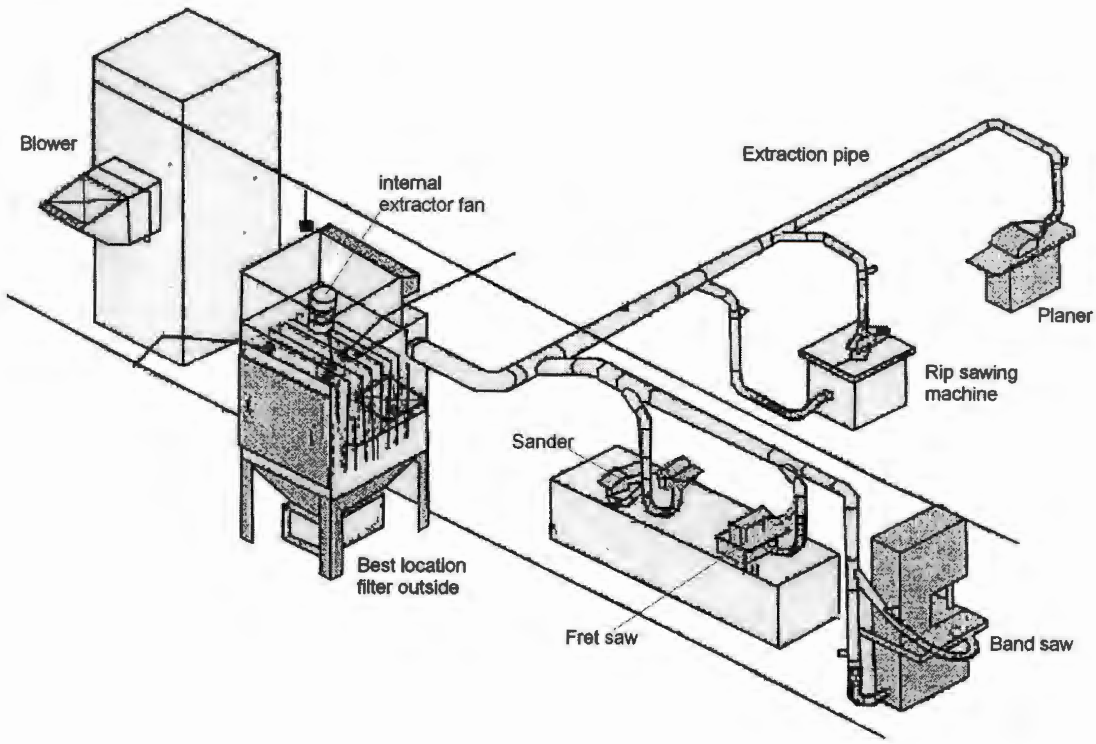


(Tool Post Dust ExtractionTechnical Manual, 2003 : 8)

The exploded view shows sequentially assembly parts of the dust extractor. The model is powered by a 12 volt direct current motor. For maximum suction secure the top section of the unit with all 3 clips. The filter is secured by the collar which is screwed onto the cover. The production and manufacturing of the hood, cover and dust collector, were done using vacuum forming process. A pre heated sheet of thermoplastic is pulled onto a prepared former by sucking out the air from beneath it. The plastic collapses and takes the shape of the former. When cooled the plastic was unclamped and the former removed. Then the plastic was trimmed to the required size of hood, cover or dust collector.

Figure 26 below shows a schematic diagram of a school workshop dust extraction system.

Figure 26: Schematic diagram of a school workshop dust extraction system



The schematic diagram shows a local exhaust ventilation system installed in a school workshop. Each dust generating machine has an exhaust hood fixed at the source of dust. The dust is sucked into the extraction pipe to be disposed off outside into the dust collector.

6.8 Summary

The careful planning and execution of all processes involved was critical to the success or failure of the project. Marking out, measuring and cutting were the basic processes which if ignored would lead to failure. The sequence of manufacturing made it easy to carry out all the operations to produce the dust extractor. Dust extractors use suction to effectively capture chips, wood dust, metal shaving, plastic grinding and debris and eliminate harmful contaminants so as not to irritate lungs. Many dust extractors are bulky and cannot be moved easily around a workstation with ease. The system designed in this study was small and easy to operate on the wall next to the machines, ensuring optimal extraction. This kept dust away from whichever project being worked on while not interrupting or affecting other learners in the workshop.

CHAPTER 7

EVALUATION OF PRODUCT, MAIN FINDINGS AND RECOMMENDATIONS

7.1 Introduction

This chapter evaluates the solution to the problem of dust and the importance of effective dust extraction methods. Helping to improve health and safety, quality of learning in a Design and technology workshop is the underlying goal of all stakeholders in education. Unfortunately, dust extraction is an afterthought in the schools' technology workshops. Learners are exposed to dust from machine processes in the workshop. The degree of importance given to finding solutions to these problems has increased considerably over the years, with big changes in health and safety legislation, increasing emphasis on learners' care and workshop safety to improve the working environment. (With the Environmental Regulations for workplaces, Machinery and Occupational Safety Act emphasizing that dust exposure limits for health at workplaces be observed (APCOR,2001:6)). I feel that dust extraction can address the health and learning concerns. Removing dust as it is generated by machine process reduces the risk of health and improves learning quality - in effect, adding value to technology education and the workshop.

This study features the new technology necessary to address these concerns. Dust extraction requirements are more lax in schools. The end result is that learners often learn in a dusty environment with enormous amounts of potentially hazardous contaminants in the air (from ineffective evacuation).There is no argument as to the detrimental health effects of air borne particulates from the manufacturing processes. The research done by the International Agency of Research on Cancer, and Applegate, as well as Union Safe Organization Studies (1995:3) show that dust is a health hazard. Though Union Safe Organization Studies and International Agency of Research on Cancer, and Applegate studies refer to the dangers of dust in industries, the technology workshop in a school is a learning industrial environment which cannot be overlooked.

The thesis looked at how dust extraction machines and systems were designed, planned, and manufactured and could be used to remove wood dust and improve the health and safety in the Design and Technology workshop.

7.2 Specification evaluation.

The solution took the form of a local exhaust ventilation where the dust from the machines was captured at the source. The extraction system developed could be used for dust control during manufacturing processes, but it has limitations as well as advantages. (Users and potential users are strongly recommended to follow standard installation procedures of control which the products can achieve, together with recommended conditions and limitations of use. All new equipment should be monitored after installation to check that control of dust is adequate).

The Multi-position or flexible arm extraction consisted of adjustable, self-supporting, flexible ducting or tubing with articulated joints, at the end of which a suitable captor hood was mounted. The proper design and position of the hood is critical to effective capture of the dust. Arm diameters typically range from 12-150 mm depending on the air flow required. The ducting may connect to a single-alone extraction filtration system or to a multi- branch **s**ystem. The advantage of this is that it has the ability to set it to an optimum position; flexibility in installation; ease and frequency of maintenance and ability to capture large amounts of dust. The disadvantage is the reliance on correct adjustment to the work by the operator; applications where the arm needs to be continually moved over a wide area; restricting movement of the operator and the work piece at the workstation.

Dust extraction hood used in the design was an enclosure with one open side or front connected to either a stand-alone or a multi-branch extraction system. It is available in a variety of shapes and sizes, depending on the machine and required airflow. The advantages are ability to control all dust at source within the enclosure; relatively low maintenance needs and no reliance on correct adjustments by the operator. The disadvantages are lack of flexibility in installation; possibly poor accessibility; and significant installation and running costs. Design and location of the extraction points must be selected with great care, with the clear aim of removing dust.

7.3 Conclusion

Today's academic environment emphasizes an increased demand for producing more and better research. This study has enhanced the understanding of technology knowledge of machine system designs and systems that might enhance the learning environment in the technology workshop. It has provided the scope for developing further research. The research experience has provided methods to disseminate new found understanding of emerging technology that can be used to provide a safe learning environment in the technology workshop.

This study explored the state of the art in knowledge utilization and technology transfer efforts. It applied findings from multiple disciplines studying knowledge utilization to the field of technology. The study identified an approach that could significantly advance efforts to produce and use knowledge and technology to improve the quality of learning in technology. With the development and use of ever more flexible machinery and plant, the early involvement of a dust extraction system at the design stages of the technology workshop will become increasingly important in producing a cost-effective and practical solution to dust control in school workshops. If the dust extraction process is approached in this manner, the cost incurred can actually add value to education, to the benefit of the government, schools, educators, and learners as well as the environment, in the education industry as well as in many others.

7.4 Recommendations

Based on the findings in the research, it is recommended that:

1. The Design and Technology Department creates a dust extraction system with maximum flexibility that can remove dust in the workshop.
2. The Design and Technology Department should have installed local exhaust ventilation systems. It is imperative that systematic attention is given to particular design guidelines for the installation of a dust extractor, which will create a healthy and safe working environment in the Design and Technology workshop. The learners' health and safety is an important aspect in design and technology education. A healthy and safe learning environment will enhance their performance.
3. Rules pertaining to health and safety with regards to the use of tools, machines and the working environments in the workshops should be known by learners and displayed in the workshops and strict adherence to these rules should be enforced. In imparting the technology curriculum

to learners, it is imperative that the educators identify health hazards in the workshop and provide a safe learning environment.

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GLOSSARY

Air cleaner: A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapours, fumes, and smoke. (Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters.)

Air filter: An air cleaning device to remove light particulate loadings from normal atmospheric air before introduction into the building. Usual range: loading up to 0.0069 g/m3 (3 grains per thousand ft3). Note: Atmospheric air in heavy industrial areas and in plant air in many collectors is then indicated for proper air cleaning.

Area (A): The cross – sectional area through which air moves. Area may refer to the cross – sectional area of a duct, a window, a door, or any space through which air moves.

Atmospheric pressure: The pressure exerted in all directions by the atmosphere. At sea level, mean atmospheric pressure is 29.92 in Hg, 14.7 psi, 407 in w.g., or 760mm Hg.

Canopy hood (Receiving Hood): A one – or two – sided overhead hood that receives rising hot air or gas.

Capture velocity: The velocity of air induced by a hood to capture emitted contaminants external to the hood. Air velocity at any point in front of the hood or at the hood opening necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the hood.

Coefficient of entry (C_e)**:** A measure of the efficiency of a hood's ability to convert static pressure to velocity pressure; the ratio of actual flow ideal flow.

Dilution ventilation (General Exhaust Ventilation): A form of exposure control that provides enough air the workplace to dilute the concentration of airborne contaminants to acceptable levels.

Dust collector: Air cleaning device to remove heavy particulate loadings from exhaust systems before discharge to outdoors. Usual range: loading 0.003 grains per cubic foot and higher.

Dust: Small solid particles created by the breaking up of large particles by processes such as crushing, grinding, filing, explosions, etc. Dust particles already in existence in a mixture of materials may escape into the air through such operations as shovelling, sanding, conveying, screening, and sweeping, enters a duct through a hood. The majority of the loss usually associated with a vena contracts formed in the duct.

Fan: A mechanical device that moves air and creates static pressure.

Hood: A shaped inlet designed to capture contaminated air and conduct it into the exhaust duct system.

Hood entry loss (he): The static pressure lost (in inches of water) when air.

Hood static pressure (sp_h): The sum of the duct velocity pressure and the hood entry loss; hood static pressure is the static pressure required to accelerate air rest outside the hood into the duct at velocity.

HVAC (heating, ventilation, and air conditioning): Ventilating systems designed primarily to control temperature, humidity, odours and air quality.

Industrial ventilation (IV): The equipment or operation associated with the supply or exhaust of air by natural or mechanical means to control occupational hazard in the industrial setting.

Loss: Usually refers to the conversion of static pressure to heat in components of the ventilation system, e.g. "the hood entry loss".

Work piece: Equipment or machinery that, while operating, generates a fume, gas vapour, or particulate hazardous to the health of units in work pieces.

Appendix. A

Questionnaire.

My name is V. Ngambi studying for a Masters Degree in Technology Education at North-West University, Mafikeng Campus. I would like you to participate in this research. The research is about Enhancing the Safety and Healthy Environment in the Design and Technology workshop. The information you will provide is confidential and will be used for research purposes only.

Thank you for your co-operation in this survey project. The purpose of this questionnaire is to understand your ideas about the present work shop environment. There is no right or wrong answer for any of the questions. Please answer the questions honestly and be as accurate as possible. Please do not write your name.

1. Do you receive any guidance with regard to protective clothing before entering the workshop?

Yes	No

2. If you answered yes in 1, how often do you receive this guidance?

Always	Sometimes

3. How many times a week do you use the workshop?

Once		Twice		3 times	

4. How much time do you spend in the workshop?

Once		Twice		3 times	

5. Do you think the frequency at which you are exposed to the dust in the workshop will cause a health problem?

Yes	No

6. Do you experience health problems due to the dust produced in the workshop?

Yes	No

7. Which major problems do you experience, mention at least 3 major ones.
8. The workshop is a risk to your health and safety.

Agree		Disagree		Not sure	

9. Who cleans the workshop at the end of the period?

Learners	Educators	Cleaning staff	Other

10. Does the workshop have a dust extraction machine?

Yes	No	Not sure

11. Is the dust extraction machine?

Effective	Not effective	Not sure

12. Will the installation of a dust extraction machine reduce the health hazards in the workshop?

Agree	Disagree	Not sure

13. How else can the workshop be improved for effective teaching and learning to take place? Mention at least 2 suggestions.

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Appendix. B

Interview schedule for staff.

1. Does the workshop have any guidance with regards to health and safety?
2. What health problems will the dust cause to learners and educators?
3. Do you think the dust produced in the workshop is a health hazard to learners and staff?
4. Is the workshop a risk to the health and safety of learners and staff?
5. Do you have any casualties as a result of the dust?
6. Does the workshop have a dust extraction machine?
7. Will the installation of a dust extraction machine reduce the health hazards in the workshop?
8. Cleanliness in the workshop – when is it done?
9. Has anyone ever raised concern about this problem to the management of the school? What was done about it.
10. How else can we improve the health and safety in the school workshop?

Appendix. C

Observation sheet.

Background to observation.

The purpose of the observation was to probe deeply and to analyze intensively the multifarious activities in the workshop with a view to establishing generalizations about the learners health and safety.

Class ___

Observation on safety and health with regard to wood dust situation during manufacturing processes in working areas in the technology workshop?

Items observed in the workshop:

1. How is the workshop when learners enter?
2. Are learners protected in terms of ventilation in the workshop?
3. The effects of dust on learners in the workshop.
4. What happens after work?
5. How are the learners after the lesson is over?
6. How is the workshop environment after learners have left?
7. The table below shows processes and frequency of use of machines in the workshop.

PROCESS	**FREQUENCY**	**HIGH** dust pollutant	**LOW** dust pollutant	Need for Extractor
Drilling				Y/N
Marking out				
Sanding				
Cutting				

Filling				
Turning				