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Chemical Management Practices of Basic Science Teachers

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Abstract

The study investigatedlower secondary Basic Science teacher's professional practice with chemical management in schools. The study sample included 70 schools in the Western VitiLevu education districts in Fiji. The participants' practice with chemicals in their Basic Science teaching and learning was studied. The data were collected by questionnaire, semi structured interview, documentary analysis and observation. A triangulation method was used to analyse the data. Results indicate that the participants had poor understanding of chemicals and therefore displayed unsafe handling, storage, usage and disposal practices. The participants lacked the knowledge to sufficiently manage chemicals for their personal protection and did not have any sensitivity of the effect of chemicals in the society.These results are discussed in relation to the literature on chemical education, chemical management, chemical literacy and scientific literacy more generally.

Introduction

Chemical Education (Chemistry) is recognized as a very important school subject and its significance in scientific and technological development cannot be overemphasized (AdesojiandOlatunbosun, 2008).Chemistry forms an important component in the Basic Science curriculum and then later in the upper secondaryit is made a core subject among the natural sciences and other science related courses in Fiji as well as in many countries in the world (AdesojiandOlatunbosun, 2008; Ministry of Education (MoE), 1997, and Emovon, 1985).

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Chemical Education reforms (Jong, 2006) suggest that context plays an important role in the usefulness of Chemistry learning outcomes to the learners and the learning experiences that learners get are useful. Jong (2006) claims that there are basically four domains of origin of context; namely Personal domain; the Social and Societal domain; the Professional Practice domain; and the Scientific and the Technological domain.

The purpose for teaching Chemistry ultimately is to develop a chemically literate individual who is a more informed citizen and understand reports, discuss about Chemistry in media and better understands environmental issues, which are more prevalent now. Understanding Chemistry is very critical, because our physical environment is heavily affected by Chemistry and filled with chemical products (Gilbert and Treagust, 2009).Thus, understanding Chemistry and the ability to apply that understanding to daily life is what is referred to as Chemical Literacy (CL) (Tsaparlis, 2000).

It is however, important to understand that all the domains are interdependent and are intertwined .For the purpose of this research, the first two domains are given importance as in the lower secondary; the researchers consider the personal and the social and societal domain to be more appropriate to develop through Basic Science.

The researchers argue that thorough focus of Basic Science Education on these two domains of development would enable learners to perceive Chemistry as meaningful (Adesoji, 1999; Johnstone, 2000; and Holbrook, 2005) and contribute towards development of CL and encourage students to choose Chemistry related career paths at a later stage.

With the goal of achieving CL, the focus of Chemistry education in Basic Sciences thus covers a wide range of intended targets in the intellectual, personal and social domains. Holbrook cautions that although conceptual learning in Chemistry is given importance, the learning and teaching "must not lose sight of the fact that the attitudes, communication abilities and personal attributes (such as creativity, initiative, safe working) need to be developed." (2005: 4). This suggests that learning and teaching of Chemistry ought to begin with the personal, social and societal approach.

World Health Organization(WHO)(2004) in collaboration with the United Nations Environment Programme(UNEP) and the International Labour Organization(ILO) in their report expressed concern that children tend to touch, test and explore their surroundings, getting in contact with toxic chemicals unsafely used or stored. Chemistry and chemicals have a central place in science, and safe chemical practices should be the most basic and fundamental part of any lesson.WHO (2004) in collaboration with the UNEP and the ILO strongly emphasize that good chemical safety habits early, better prepare students to learn how to work safely and develop their individual sense of responsibility and good habits for the safe handling and use of chemicals.

Effective chemical education from and early age may contribute to children developing appropriate behavior and skills of chemical management in daily life.Chemical Education reforms (Jong, 2006) suggest that context plays an important role in the usefulness of Chemistry learning outcomes to the learners and the learning experiences that learners get are useful. This tie well with the overall goal of science education: scienctific literacy.

The responsibility for the development of such desirable attributes in children from an early age is important. Teachers may be very influential in developing of appropriate chemical management skills in learners.

According to Adesoji and Olatunbosun (2008: 16), in any “teaching - learning situation, the students, the teachers, the curriculum and the learningenvironment are the four pivots”.Teachers play an important role in the development of Chemistry education and their knowledge and understanding of chemicals may impact on the development of the same in learners.

Hattie (2003) aptly says that teachers are the single most important source of variation in the quality of learning. Papanastasiou (2001) affirms that teacher’s role during the learning process can directly or indirectly influence student attitude and hence student learning outcomes. Teachers, according to Papanastasiou (2001:20), are “role models whose behaviors are easily mimicked by students”.

Since teachers are such an important variable in student learning, it is important that teachers are good role models who have appropriate cognition, skills and behavior when teaching about and handling chemicals in the course of teaching Basic Science. It is hypothesized that if teachers have appropriate chemical management skills than students are very likely to develop favorable knowledge, skills and disposition towards the impact of chemicals in their personal and public lives as well as be groomed to understand its impact on the environment. A teacher's conceptual understanding of chemical management in Basic Science influences teacher pedagogy(Joshua and Basey, 2004). This may send important messages to students about the importance and value of chemical education.

This study considered teachers knowledge, understanding and practices of chemical management a critical starting point for the development of CL.

The Study

The study investigatedthe level of CL of Basic Science teachers by ascertaining teacher's knowledge and practices with chemical management practices in school. The key question underpinning the research: Whatis a level of Chemical Lliteracy of Basic Science Teachers?

The following questions underpinning the key questions guided the study:

1. How familiar were the teachers with the Material Safety Data Sheet (MSDS) of chemicals that are used in Basic Science classes?
2. How are teachers using their understanding of Chemical Management in their professional practices?
3. How relevant was the Ministry of Educations' Occupational Health and Safety policy in developing a culture of safe practice in chemical management?

Methodology

The study used a triangulation mixed method design, which is a procedure for collecting, analyzing, and "mixing" both quantitative and qualitative research and methods in a single study to understand a research problem (Creswell, 2006, Johnson, Onwuegbuzie& Turner, 2007).

Triangulation design was used where “data was obtained differently using qualitative and quantitative tools but the data complemented on the same topic. This design is also referred to as the “concurrent triangulation design” (Creswell, 2006: 64).

Sample of the Study

The population boundary for the study was the schools in the Western Division of VitiLevu, the largest Island in the Fiji archipelago, which comprises of four districts, namely Ba/Tavua; Lautoka/Nadi/Yasawa; Ra and Nadroga/Navosa.

From the population sample, 25% of the Primary and 25% of the Secondary schools were randomly selected for data collection. The sample comprised of 54 Primary schools and 16 Secondary schools from the Western Division. The exact number of selected schools in the different districts depended entirely on the total number of schools in each district. A large sample was taken to validate the findings of a similar research by Shah and Sharma (2010) to ensure that the findings can be generalized for all the schools in Fiji.

For the Primary schools, the target group was the Upper Primary (Years 7 & 8) Basic Science teachers; whilst for the Secondary schools, the target group was the Lower Secondary (Forms 1-4or years 7,8,9,&10) Basic science teachers. Years 7 and 8 of the primary schools secondary schools follow the same curriculum. The term, lower secondary has been used collectively to include the upper primary and lower secondary years where Basic Science is a compulsory subject. Specific mention has been made to Primary and Secondary schools when distinction in data was noted between the two. The generalised term, Lower Secondary is mentioned otherwise.

Data Collection

The qualitative data was derived from semi-structured interviews of Department Heads (Secondary) /Science Teacher-in-charge (Primary), through observation of the science laboratories and science cupboards/classrooms and documentary analysis of MoE and School Occupational Health and Safety (OH&S) policy and Chemical inventory logs.

The quantitative data was derived fromquestionnaire survey. Questionnaires were given to the Basic Science teachers, who were asked to fill in the questionnaires under the researcher's supervision. This was done to eliminate any form of bias and external influence that could have affected the results. Considering research ethics (the use of human subjects as research participants), consent was sought through the school leaders to interview Science Department heads and science teacher-in-charge and use science teachers to fill in the questionnaire.The number of questionnaires depended on the school size and the availability of the Basic Science teachers.

The Data Analysis

The researchers' valued both the forms of data as such an almost equal weighting was given to both the quantitative and qualitative analysis. The questionnaire was analyzed as basic percentage counts and the data obtained from the semi-structured interviews, laboratory observations and documentary analysis was analyzed qualitatively. The quantitative data was merged with the qualitative data during the analysis to obtain a better picture of problem that was investigated (Creswell, 2005).

Significance of the Study

There is a dearth of local literature in this area of study. In fact the researchers are of the view that this is the first research that has been undertaken in Fiji. Hence the study is significant for several reasons.

Firstly, it will create awareness on the importance of educating the Basic Science teachers on Material Safety Data Sheet (MSDS).

Secondly, the outcome of the study expects to stimulate in - service teacher professional developments on MSDS and appealto authorities to prioritize and scrutinize chemical management policy and practices in Primary and Secondary schools in Fiji at National, District and Institutional level.

Thirdly, it is anticipated that the findings will point out that exhibiting appropriate chemical management behavior is not a casual affair. It must be consciously practiced by the most influential variable of teaching and learning: the teachers (Papanastasiou, 2001).As such continuous professional development activities for teachers need to be initiated to increase the level of their SL and CL

Theoretical Framework

The theory on scientific literacy and chemical literacy provide the theoretical basis for the study. Scientific literacy refers to the possession of knowledge to understand the interrelationship between scientific facts and science, technology and society and the ability to apply it to real world problems (Bond, 1989; Celik, 2014). The scholarly literature on scientific literacy points out that," 'scientific literacy' is one of those terms often used but seldom defined."Miller (1983), inAnelli (2011:238).

The definition that best fits this study was an argument by Feinstein (2011: 170-171) who expressed that, Science education should focus on the "usefulness aspect" of scientific literacy; that is, the degree to which science education actually helps people solve personally meaningful, everyday problems and make important science-related decisions.

The prime goal of science education is to participate in the education of citizens as -'lifelong learners', who should be competent in knowledge and skills and be able to make decisions and participate in public debates on science and socio-scientific issues.

As scientific literacy is a broad concept, teaching any special subject in science education should contribute to the goal of training scientifically literate people. Teaching Chemistry contributes to chemical literacy in particular, and to scientific literacy in general (Shwartz; Ben-Zvi; &Hofstein, 2006).

Schwartz et al. (2006)and DeBoer (2000) summarised the many proposition made by other researchers, suggest that thereare basically 3 distinct levels of scientific literacy at which an individual can operate. The three levels from the lowest to highest competencies are:

1. Practical or functional literacy - refers to the ability of a person to function normally in his/her daily life as a consumer of scientific and technological products, such as food, health, and shelter;

2. Civicliteracy- refers to the ability of a person to participate wisely in a social debate concerning scientific and technologically related issues; and

3. Cultural or idealliteracy - includes an appreciation of the scientific endeavor, and the perception of science as amajor intellectual activity.

Bybee (1997) and theBiological Science Curriculum Studies (BSCS) (1993) suggested a comprehensive theoretical scale that is more suitable for the assessment of scientific literacy during science studies at school, as its hierarchy can be easily transferred to instructional purposes. This study considered the scale useful in ascertaining teacher's level of chemical literacy. The scale suggests from the lowest to the highest level as follows:

Scientific illiteracy: Students who cannot relate to, or respond to a reasonable question about science. They do not have the vocabulary, concepts, contexts, or cognitive capacity to identify the question as scientific.

Nominal scientific literacy. Students recognize a concept as related to science, but the level of understanding clearly indicates misconceptions.

Functional scientific literacy. Students can describe a concept correctly, but have a limited understanding of it.

Conceptual scientific literacy. Students develop some understanding of the major conceptual schemes of a discipline and relate those schemes to their general understanding of science. Procedural abilities and understanding of the processes of scientific inquiry and technological design are also included in this level of literacy.

*Multidimensional scientific literacy.*This perspective incorporates an understanding of science that extends beyond the concepts of scientific disciplines and procedures of scientific investigation. It includes philosophical, historical, and social dimensions of science and technology. Here, students develop some understanding and appreciation of science and technology regarding its relationship to their daily lives.

More specifically, they begin to make connections within scientific disciplines, and between science, technology, and the larger issues challenging society (In Shwartz, Ben-Zvi&Hofstein, 2006: 204).

Since Primary Education is the starting point for the development of scientific literacy, the development of the lowest level is important. Dewey (1934: 3 , inAnelli (2011: 235 -236), based on a survey of science teachers across the U.S called for educators to train all students to develop a “scientific attitude” or “habit of mind,” suchthat they would exhibit “open-mindedness, intellectual integrity, observation, and interest in testing their opinions and beliefs”. As alluded to earlier, the earlierthis development begins, the better (WHO, 2004).

Anelli (2011:238) along with several experts including the National Science Education Standards (NSES), provide compelling arguments for the importance of scientific literacy; they are firm in the belief that all students deserve the opportunity to become scientifically literate.

Development of good chemical management skill is important in Basic Science lessons. Lessons which are activity oriented and authentic are appealing.Šorgo and Špernjak (2012), and Liapi and Tsaparlis (2007), recognise Chemistry as basic experimental science where experimentation is a basic method of school work. The experimental nature of Chemistry implies that chemical will be used in science classes. The management of chemicals thus becomes important in promoting CL.

Chemical Management

Chemical management (CM) is a plan that identifies, manages, and prevents hazards through all stages of chemical purchasing, storage, use, and disposal. According to EPA (2006), CM is critical to controlling a variety of environmental, health, and safety issues within any school. The knowledge of what sort of materials are present in schools and how they are used, stored, and discarded develops an understanding of the issues associated with these substances. Properly recognizing and controlling the hazards inherent to these materials, enhances the schools ability to create a safe school with minimal environmental liabilities/lawsuits (EPA, 2006).

Chemicals are accompanied with a Material Safety Data Sheet (MSDS), which is a document relating to a chemical substance that covers the chemical composition of the product, its name and essential physical properties, such as boiling point, vapour pressure, reactivity and odour. Furthermore, it defines the hazards including fire and exposure and safety measures including protective gear associated with the chemical substance. MSDS provide the necessary information for one to understand and deal with the potential hazards associated with a particular substance (Volland, 2008).

The importance of MSDS is twofold. On one hand, it provides employees with all the necessary information they need to ensure they are using a product correctly ,on the other hand, it informs employees of ways to protect themselves from the hazards of the product by providing safe handling and storage procedures, procedures in cases of emergency or fire, and what personal protective equipment (PPE) needs to be worn when dealing with these chemicals.

Chemicals can be very dangerous, especially if they are being repeatedly handled without proper procedures. They can pose many health and physical risks. In addition, having general knowledge about the product such as colour, physical state, or flashpoint will help ensure a safer work environment for those involved. MSDS is also important when it comes to emergency responders or medical personnel (Volland, 2008).

A survey of K- 12 schools in 55 states in USA, found that a large majority of middle and high schools had out dated, unknown, improperly stored or unnecessary chemicals with potential of high risk (EPA, 2006). Similar findings were recorded by Michigan Department of Environmental Quality (DEQ, 2009) and National Research Council (NRC, 2011).

According to EPA (2006) and DEQ (2009) some important components of proper CM are; chemical inventories, chemical cleanout and disposal, proper labelling, storage, and handling, purchasing guidelines, Chemical Safety and Training and Education. These components along with many others play a significant role in developing a proactive attitude towards chemicals amongst teachers.

Role of Organization

Leaders play a significant role in ensuring safety for their workers. It is the responsibility of the employer to ensure that the MSDS sheets are available to the workers and that the workers acknowledge their existence and is educated on the potential hazards exposure in the workplace. A supportive culture is needed to graft a safety culture onto an organization (Department of Consumer and Employment Protection, DOCEP, 2007).

Both personal and organisational attitude affect the development of a safety culture in a workplace.The environment in which people work and the systems and processes in an organisation also influence the safety culture.Safety is a shared responsibility between teachers, students, administrators, and parents and should be a national, district and school policy, not the policy of an individual teacher (EPA, 2006 and DEQ, 2009).Organizational chemical management policy may contribute to the development of a safety culture. In USA, all states, districts and schools are mandated to have a CM policy (EPA 2006). Organisational attitude can positively influence personal attitude of teachers and learners.

Many teachers and administrators give low priority to the understanding of regulations, best classroom practice, and facilities preparation for safety with chemicals (Trammell, 1995).School science accidents have been attributed to several factors, namely (1) new performance-based science standards that require more hands-on work in laboratories, (2) inadequate safety equipment in schools, and (3) lack of adequate training of teachers. Ongoing professional developments and trainings are important in the development of positive attitudes of safety culture.

Gerlovich (2002) in a survey of 18 States in US, found that over half of the science teachers had never been trained in safety. Many high school chemistry teachers have primary degrees in other fields and may only have taken two years of college Chemistry. In Fiji, Primary teachers are trained as generalist teachers. Some of these teachers may not have done pure sciences upto form seven. This fact in itself raises vital questions on the competency of the CM skill of teachers. The undergraduate primary teacher training programs need a re- examination.

Like any other activity, safety is learned by continual reinforcement (Trammell, 1995).Safety in the science laboratory requires common sense, preparation, and knowledge on the part of both the teacher and students. The use of unfamiliar equipment and chemicals in the science laboratory requires extra rules for behaviour (Trammell, 1995). Teaching students the proper way to handle materials in the school laboratory should also help them learn correct handling of chemicals found at home or on the job. Safety education must be an ongoing process and cannot be taught only once during the year. Students cannot be expected to remember everything from the safety lecture given during the first week of class. The implication being that it must be continuously practiced intentionally by teachers to develop the same attribute amongst students who later can use this understanding

Material Safety Data Sheet (MSDS) is a document relating to a chemical substance that covers the chemical composition of the product, its name and essential physical properties, such as boiling point, vapour pressure, reactivity and odour. Furthermore, it defines the hazards including fire and exposure and safety measures including protective gear associated with the chemical substance. MSDS provide the necessary information for one to understand and deal with the potential hazards associated with a particular substance (Volland, 2008).

Many may argue that in Basic Science curriculum, chemicals are not potentially hazardous. However, a list by EPA (2006) of the top forty risk chemicals in schools shows that there are a significant number of potentially hazardous chemicals used in Basic Science experiments.A few of them are sulphuric acid, acetic acid, mercury thermometer and hydrochloric acid.

In a study of intermediate school cupboards clean-up in all States in USA, EPA(2006) found a large number of school science storage containing chemicals such as asbestos, unknown radioactive chemicals , and many carcinogenic chemicals unknown and improperly stored in cupboards as it passed on from one teacher in authority to another. It is possible that a critical look at the science inventory recording system and science cupboards in schools may show teachers, the existence of many chemicals that are old, unused and potentially dangerous in schools in Fiji.

Results and Discussions

Familiarity with Material Safety Data Sheet / MSDS of chemicals

53% of the surveyed population (N=37) had MSDS awareness especially when purchasing chemicals(Figure 1). This 53% sample represented 44% of the Upper Primary teachers (N= 24 out of 54) and 79% of the Lower Secondary teachers (N = 13 out of 16).More than half the primary school teachers are unaware of MSDS indicating a lack of training and explicit awareness at organisational level. It may also indicate a need to include chemical management education in the pre- service and in service teacher training programs by responsible institutions especially in primary teacher training program.

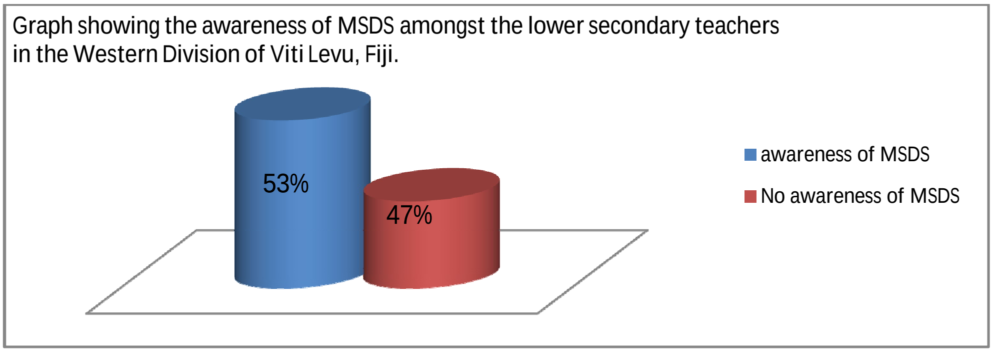

Figure 1: Showing the Awareness of MSDS Amongst the Lower Secondary Teachers

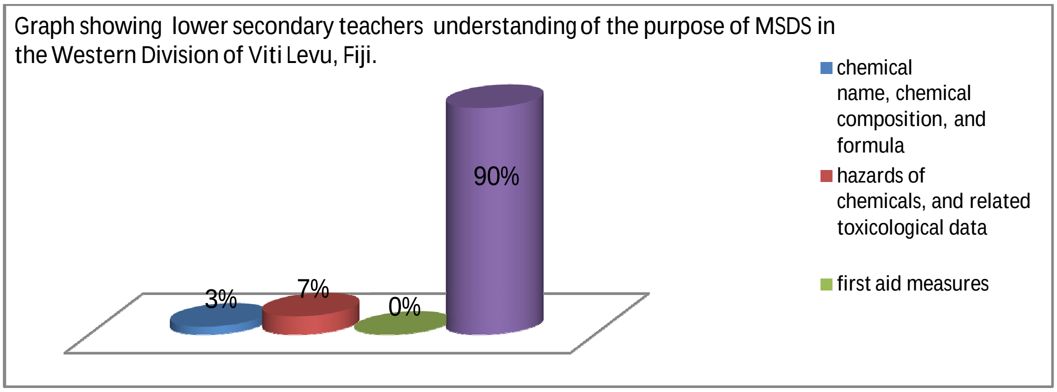

Figure 2: Showing the Understanding of the Purpose of MSDS Amongst the Lower Secondary Teachers in the Western Division

In the same vein, in the questionnaire survey 90% of the population (N= 63)knew the sum purpose of MSDS (Figure 2).However, their interpretation skill of MSDS was questionable. 96% of the interviewees (N= 70) when given a sample MSDS, could notinterpret the contents of MSDS. For example, when the toxicological informationabout "Copper sulphate [LD 50:300mg/kg-rat]"was given , teachers pointed out thatchemical was toxic by recognizing the term 'toxic' in the term toxicology but were unable to interpret the numerical value of LD (lethal dose) that can kill a rat and what it means when they are using it in class. Similar explanations were given to terms such as carcinogenity of substances.

A surface level of understanding of science terminologies to the exclusion of it meaningful use and application dominated the discussions. Sampled teachers were able to regurgitate the definitions of terms but were unable to apply to useful context indicating the need for explicit awareness of MSDS. Volland (2008) and EPA (2006) lend support that MSDS training at organisational level can improve CM practices of teachers as MSDS is one of the important components of safe CM practices.

The teachers thus appear to be operating at the lowest levels of SL; nominal /functional literacy (Schwartz et al., 2006) and DeBoer, 2000). With this level of understanding of chemicals teachers use in science classes, it is thus doubtful that teachers are focussing on the development of CL in students targeting their personal and social and the societal domain (Jong, 2006).

The ensuing discussions and results show CM practices in school which confirms the doubt above.

Firstly, a shocking revelation through questionnaire survey and interview with teachers showed that chemicalcompanies do not supply MSDS to schools. 5%of the samples (N=4 out of 70) do request for MSDS from chemical suppliers however, they are not supplied with one. Some teachers download the MSDS from the internet mostly from personal sources as most schools are not equipped with internet facilities.

The MSDS in schools are stored in the science laboratory files (N= 3), but as teacher X said in an interview;

"the file is with the head of departments and they have to ask for it if they need to use it"

This indicates that teachers do not have a copy of the MSDS readily available for use. The argument is that it must be in the laboratory or in a place readily accessible to teachers.

On the other hand, 95% of the samples do not have MSDS access in their school. These teachers often rely on the labels of the chemical containers for information about the chemicals and relate the same to their student. The labels on chemicals have limited information whilst the MSDS has detailed and complete information deemed important for proactive planning

Teacher's use of Chemical Management in Professional Practice

Chemical Handling and Disposal in Schools

After a chemical usage in class, 99% (N= 69) of the teachers dilute chemicals before discarding. Of which, 78% (N=54) discard in either sinks or in drains, which eventually lead to nearby drains and/or a water body nearby the school. Whilst, 22 %(N= 15) teachers get students to discard the chemicals on the ground, in incinerators, in soak pits and even in pit latrines after dilution. Discarding chemicals in such areas is considered 'safe' by the Basic Science teachers as there is minimal student access to these areas. This is more common in rural and remote schools. It is a concern that teachers seem to be ignorant in their responsibility for environmental awareness in CM which is a social responsibility, an important component of CL (Jong, 2006).

Theuse of students to carry and dispose chemicals is a cause for concern. More than 80% (N> 56) of the surveyed schools used students to dispose chemicals after investigations. Most Primary schools used their students to carry chemicals to and fro classroom which in some cases were unsupervised. This practice is unsafe and is not compliant with the Occupational Health and Safety (OHS) Policy (MoE, 1997).The OHS policy (MoE, 1997) states clearly the role of teachers and school pertaining to safety in laboratories for example;

> *Teachers who want to use the science materials/ equipment should personally take materials from the teacher in charge. Extreme care must be taken when moving chemicals from one room to another. All safety regulations must be displayed and followed.*
>
> (MoE Policy in Occupational Health and Safety: 1997)

The Policy appears to assume that teachers are aware of the safety regulations for proper chemical management. It has been found that the teacher's conception of safety with chemicals is restricted to student safety whilst it is being used during lessons. Although, all teachers were found to be very particular about safety of students during experiments, this did not translate in action, as students were used to carry chemicals to and from their classrooms, dispose and clean glassware containing the chemicals. Students were exposed to chemicals without even having proper PPE.

Several issues arise from the above data. Firstly, it may be due to the limitation of explicit protocols for chemical usage and disposal in the MoE OHS policy.Teachers are unaware of the appropriate way to exhibit safe behavior for chemical use. All schools in the survey had OHS rules displayed but safety seemed to be a concern only for making sure that no student was harmed. Argument is that safety with chemicals is as much for individuals as it is for all the living things in the community. When put broadly, it must be linked to the society and the environment as a whole .So when it comes to safety; teacher's main concern for safety is related to avoiding student accidents and not being sensitive to the needs and demands of the chemical in terms of its storage, usage, and disposal and its impact on the environment and other living things. Teachers' self- skill in chemical safety is questionable.

One of the most important factors in effective learning is teachers as role models.Inaddition; one of the important components of CL is being able to apply knowedge of chemicals for personal and social use. It may be an indication that teachers are operating at the lowest nominal levelof scienctific literacy.

In addition, safety only when using chemicals may send an incorrect message on the safe use of chemicals. Safe use of chemical is more than personal safety(Jong 2006).It is reiterated that the teacher's behavior towards chemical usage sends very important messages about the purpose of chemical education to students (Hattie, 2003; Jong 2006; Joshua and Basey, 2004; and Papanastasiou, 2001). In this case, Chemical Education does not emphasise the development of the social and the societal domain (Jong, 2006).

Chemical Storage in Schools

Observation of Science cupboards showed that chemical storage was problematic and must be considered a major issue in CM practices. Chemicals have been found to be stacked together irrespective of their class and property in 90% of the surveyed schools. None of the Primary schools visited, had proper chemical storage. Chemicals were stacked in cabinets or open cupboards, with least concern given to the class of chemicals.

Many chemical containers were so old that there were cracks in the containers and the contents were spilling out, whilst in some schools chemicals were not stored in properly labeled bottles or different bottles were used for chemical storage. The science chemical cabinets were stacked with both chemicals and science equipment, especially for Upper Primary Schools.

For the Secondary schools, chemicals were stored separately from the equipment and glassware in most cases. Storage of chemicals varied in the sampled secondary schools. 10% (N= 2 out of 16) of the schools stored chemicals according to their class; this was noted for those teachers with an awareness of MSDS. In the other 90% (N= 14 out of 16), chemicals were stored according to the alphabetical order which meant that different class and property of chemicals were stacked together. Liquid chemicals such as acids were usually placed on the very bottom shelf for 90% of the schools.

Furthermore, the design of the science chemical cabinets was not of standard. Some science chemical cabinets had a height exceeding 2m, with the chemicals placed on the top shelves which required the use of stools or benches. This in itself posed risk and was an OHS issue (DEQ, 2009; EPA, 2006; and WHO, 2004).

The location of the storage area was also an area of concern. The location was inappropriate in all the Primary schools because the cupboards/ cabinets were stored in commonspaces such as the library, staff room or even classrooms.Students were also given permission to remove or put back the chemicals from these cabinets before and after use in classes. On the other hand, the Secondary schools had proper chemicals storage facilities.

There was also poor ventilation in the place where chemicals had been stored especially for primary schools and some secondary schools.

Moreover, storage of expired and excessive chemicals was also identified. In some schools, chemicals had been stored for so long that chemicals had actually leached out of the bottles. One such scenario was for a secondary school where nitric acid had leached out of the bottle. In some cases, chemicals had decomposed in their respective bottles, with the teachers unaware of what to do.Overall, most of the secondary schools had chemicals in excess of the required amount .This is consistent with the finding of EPA (2006) which found that high schools usually have larger inventories and more hazardous chemicals than middle and elementary school (EPA, 2006).

On the other hand, whilenone of the Primary schools had excess storage of chemicals, they did have very old unlabelled chemicals in small quantities.These unlabelled chemicals could be anything and can only be identified by chemical experts during a chemical cleanout (EPA, 2006).In addition,9% (N =5 out of 54) possessed chemicals which was of no use to the Basic Science curriculum.Furthermore, most of the chemicals that were labelled in primary school science cupboards were either expired or near to their expiry date.

An interesting yet thought provoking revelation through interview with teachers during science cupboard observation showed that there was confusion between liquid and solid chemicals. A significant 19% (N=10/54) regard liquids as chemicals only. Although this represents only a little less than one fifth of the Upper Primary teachers surveyed, teachers can be a significant source of misconception for students in the Primary schools (Skamp, 2004). Furthermore, this also raises the concern about the handling of solid chemicals especially if it is not considered a chemical.

Chemical Inventory

Chemical inventory is an important aspect of Chemical storage. Observations of chemical inventory records show that none of the participants in the study had proper records. Records were limited to the names of the chemicals and the date of receipt.

According to EPA (2006: 72);a chemical inventory identifies the quantities and physical locations of, as well as the potential hazards associated with, all of the chemicals used and stored in a school. It also serves as a reference for school and emergency personnel (e.g., local fire department) in the event of an emergency. Furthermore, a chemical inventory, when used to guide necessary purchases, can reduce the costs and management needs associated with excess chemicals.

The limited nature of the inventory records in the schools in this study may be linked to the storage of excessive and out-dated chemicals in schools. Inventory of chemicals is more than a record of resources. It must be a living document where status of chemical after every use is updated and a document which can be referred to in times of emergencies to find out the hazardous properties of chemicals.

Laboratory Safety Accessories/Necessities/Professional Development

In majority of the Secondary schools visited, the presence of safety accessories such as a fire extinguisher, bucket of sand (in case of a fire), safety shower, fire blanket and first aid kit were noted. This was an indication that teachers were aware of safety issues around work areas.

However, in most Primary schools, equipment such as a fire extinguisher and first aid kits had been placed in the head teacher's office.Since Primary schools do not have a separate science space, consideration of safety accessories in every classroom is perhaps overlooked.

The training on safe CM practice is not given importance in promoting a safe working environment. Data shows that although teachers are briefed on OHS issues in every staff meeting and student's safety issues are given high priority ,all the participants reported that training about chemical and chemical management has never been raised as an issue of importance. About 30% (N= 21) of the teachers do remember participating in one professional development workshop related to chemical safety organised by Curriculum Development Unit; Ministry of Education some time ago. It must be noted that continuous emphasis and training is essential in the development of proper CM practices (Trammell, 1995).

Hence, it appears that in service teacherswere not explicitly trained and made aware of proper CM. It may imply that the MoE assumes that teachers' have been trained on proper CM in their undergraduate program. It must be understood however that continuous professional development of teachers is necessary for sustaining practices that can enhance the learning outcomes of education (Darling-Hammond, Wei, Andree, Richardson &Orphanos, 2009).

Safety Contract

One secondary school in particular asked students to sign laboratory contract with the Science Department of the school. This science department had its own departmental policy and accident report form, which had to be followed by the signatories. This ensured good laboratory practice for the department and school too. When inquired, the teacher responsible had acquired this safe practicethrough University education in the undergraduate program.

Summary

The study looked at teacher's perception and practices of Chemical Literacy in schools with the view that teachers are instrumental in developing Chemical Literacy in learners which will contribute towards achieving the broad goal of Science Education. The study was based on the premise that teacher's level of Chemical Management practices was a window through which their competency of Chemical Literacy and broadly Scientific Literacy could be assessed.

The study found that the participants had very low level of Scientific Literacy.The participantswere operating between the nominal and the functional literacy levels.This implies that the participants understanding of chemicals and its meaningful use is limited and clouded with misconceptions (Bybee (1997);BSCS (1993), in Shwartz,Ben-Zvi&Hofstein, 2006).

This is a serious issue as teachers are the role models for the students (Papanastasiou, 2001). The importance of teachers with conceptual understanding of the subject matter, in this case proper chemical management , influence significantly the type of learning environment given to students.

The study found that the current chemical management practices of the participant are focussing neither on the personal domain nor on the social and societal domain (Jong, 2006) of Chemical Literacy. It is sad to note that the participants are not even at the personal domain of Chemical Literacy. Since Chemical Literacy is a component of Scientific Literacy, emphasis on the development of these two domains will ultimately contribute to the development of first nominal literacy and then functional Scientific Literacy making way for other levels to be achieved as learning progresses.

Although the study was limited to the schools in the Western Division of VitiLevu, the researchers are of the view that the findings can be generalized. The findings of this research is consistent with the findings of a similar research carried out by the Shah and Sharma (2010) on a smaller scale .

The study has found that there may be several factors that are contributing to the low level of Chemical Literacy in the participants. They are as follows:

1. The lack of explicit policies on Chemical Management.
2. The lack of continuous training and education explicitly on Chemical Management.
3. The lack of importance and emphasis given to Chemical Management in schools as a panacea to environment problems

Thus the study has one very strong implication amongst others,which if addressed could start a ripple of changes in the development of proper chemicalmanagement skills in teachers ,the most important variable in effective learning and teaching process. The implication is that there needs to be a review of thecurrent Occupational Health and Safety Policy (MoE, 1997) to include Chemical Management as a priority area in creating a safe and healthy working environment A National Chemical Management policy is a good starting point in the attempt to improve chemical literacy skills of teachers.

This study recommends that chemical management needs to be included in teacher education programs especially for primary teacher trainees. Accidents have not occurred thus far should not be cause for joy. The Ministry of Education needs to develop and on- going professional development of teachers on chemical management.

In conclusion, the findings of the research indicate that Chemical Management practices in schools are in a shabby state and it is surprising that major accidents have not occurred thus far. But the whole rationale for Chemical Management is to be proactive and not reactive (EPA, 2006; WHO, 2004).

The researchers thus hope that the findings of this research will contribute significantly towards creating a safe learning and working environment in schools in Fiji. It is important to emphasise that teacher's role as the most influential change agent in education cannot be overlooked (Hattie, 2003; Papanastasiou, 2001). The poem below attempts to capture the importance of education in the Pacific society influenced by chemical pollutants:

The Pacific Destiny

Plight of the Pacific
In the bosom of posterities
Education panacea
For the depleting Pacifica

Chemicals both natural and synthetic
Creeping steadily and surely
Exultant in stature
Leaching and pervading
Eroding and exploding
The core of creation
Like the calm of a tsunami

Trepidation and tension
Creasing the brows of intellectuals
Searching for solutions
Reviving the essence of existence
Unique to Islanders

Children our hope is not a cliché
Educating rightfully is the only way
A proactive stance
A definite chance
For nurturing nature
Alongside innovations
Achievingliberation unique to Pacifica

By Runaaz Sharma

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