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Helpdesk Report: Desk construction materials and their longevity

Date: 22nd February 2012

Query: Evidence to support or refute a supposition by Government that desks made of plastic are longer lasting and more cost effective/ better VFM than the traditional 3-seater wooden variety found in most African schools.

1. Overview

School desks are very important and there has been a lot of research to show their impact on improving learning, more so, in fact, than a school building does. Research has shown that physical facilities have more of an impact in developing countries than in the UK and USA (Fuller, 1990).

There any many things to consider when deciding between wooden and plastic desks. In industrialised countries, educators define furniture needs based on catalogues and showroom samples. This approach is often not applicable in developing country settings. Any comparison is easier with mass produced products as otherwise, the variability between each type of desk is too great.

Research has found competing results (see key resources section):

- 'attractive, sturdy, easily maintained furniture can be produced from local woody materials at a modest cost in any developing country'.
- 'The project was obliged, therefore, to work with national industry on a totally new, low cost, durable design'.

Expert Opinions

- 'Plastic chairs are better than wooden benches in terms of teaching because of their portability- easier to rearrange for group work/circle work etc. But plastic desks are often too light and not easy to write on, so wooden desks are better'.

- ‘In South Sudan many schools had tubular metal with plywood desks and chairs- many of these had broken and were already falling apart even before they had been delivered to the schools’.
- ‘With wooden furniture it can be made locally, which can be a big plus, but often difficult to get it of suitable quality, quantity and to ensure the sustainability of the timber source’.

The areas of consideration are durability, unit cost and environmental effects. These include:

Type of material- things to consider

- Grade and quality of the plastic will affect the durability of the product.
- Most soft wood species are not termite resistant, and hardwoods that are not attacked by insects are difficult to work with hand tools. Most woods found at village level will probably be unseasoned.
- Quality of wood: Previous research has shown that plywood is unsuitable for the desk top.

Construction-

- Well made desks will last longer than poor quality, this may be more important than material. One project estimated a 20-year expected life of furniture.
- Rough assembly techniques which may be used locally for wooden desks may not be appropriate and contribute to desks being less durable.
- Desks should be the right size for the age and size of the pupils. This is very important. Consider the sizes available of plastic desks and chairs.
- **Assembly and Installation:** Can local people be found with the skills to put the furniture together if it comes in pieces?

The setting-

- Can desks be locked away? If not, will mobile desks be stolen? If so, wood may be better if it can be fixed.
- Size of space is important when deciding the size of desk. E.g. recommendations include: flat floor of concrete or wood, non leaking roof, security, and at least 9.0 square feet per child. If there is less space 3-seater desks may be more appropriate.

Cost-

- Any VFM analysis would involve knowing the cost of each type of desk and the quality.

Environment-

- Plastic desks are less environmentally friendly and harder to dispose of.

Availability of plastic desks-

- Production capacities locally for wooden desks may be lower than needed.

<u>Key Resources:</u>

Furniture Provision: the Management Process

Chapter 3 of Myanmar: The Management Process for Constructing Primary Schools and Providing School Furniture, UNESCO, 2002
www2.unescobkk.org/elib/publications/myanmar1/chapter3.pdf
Annex F provides a useful Furniture Process Checklist
www2.unescobkk.org/elib/publications/myanmar1/annex_f.pdf

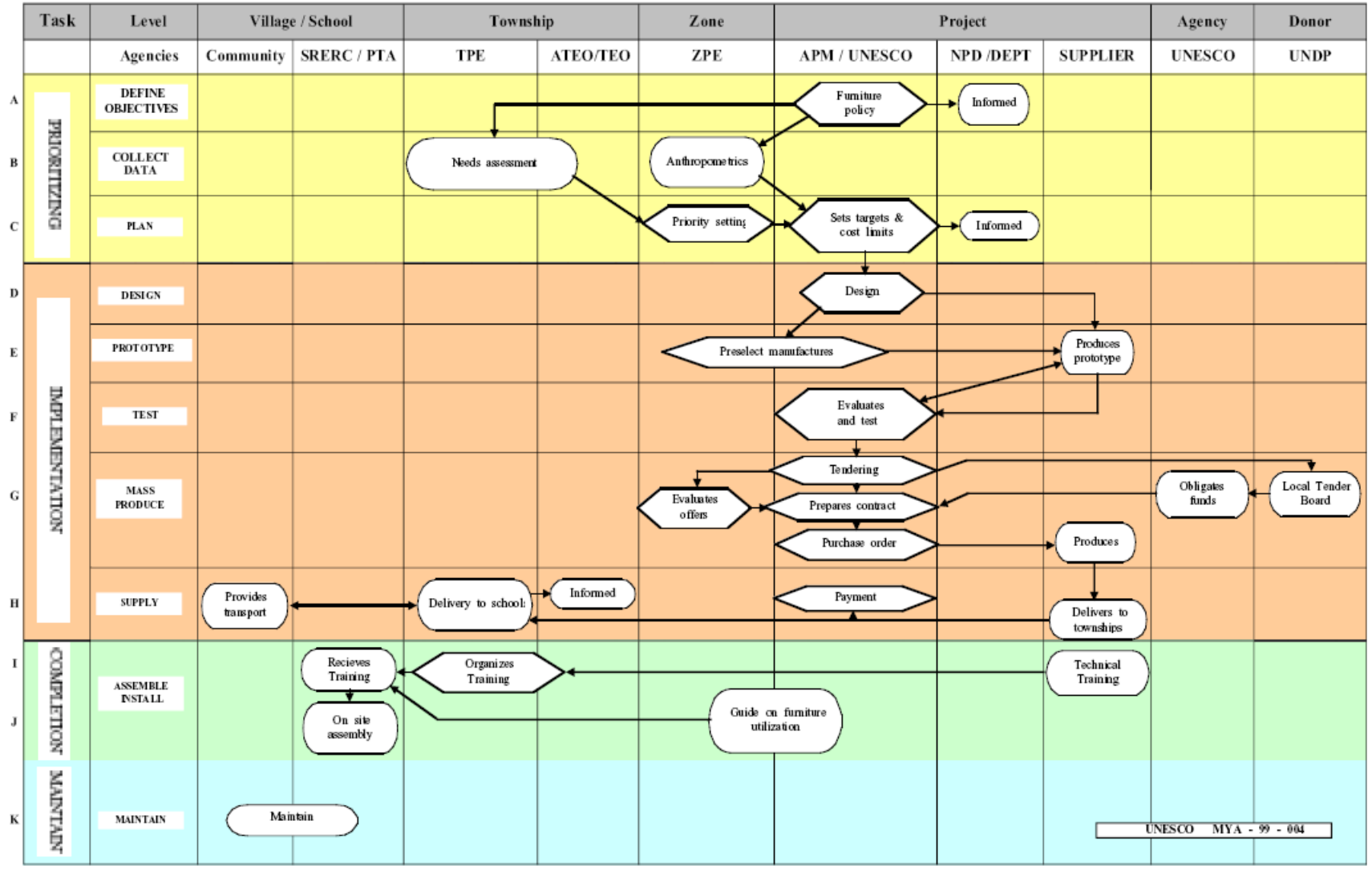
Considerations in the Design and Development of School Furniture for Developing Regions Based on Local Resources
www.freepatentsonline.com/article/Forest-Products-Journal/76559707.html

2. Considerations – quality of materials

Chairs:
The 'Helpful tips for buying school furniture' shows different styles of desks
www.furniture4schools.com/information.php?info_id=4
What is the difference between a "soft-plastic" chair and a "hard (or solid) plastic" chair? Soft plastic chairs are made from polypropylene or polyethylene plastics. These are the most cost effective student chairs and can be quite durable giving many years of use in a classroom setting. However, nothing tops the durability of hard plastic seats, backs and work surfaces. Hard plastic is made from a mixture of finely ground wood flour, melamine resin and various pigments which provide the vibrant, long-lasting look for which these chairs are known. Through a process of heat and pressure which takes place in a hard plastic press, a hard plastic piece is constructed. In addition to resisting stains, hard plastic is non-warping and remarkably chip-resistant.

Considerations for wood:
Furniture Provision: the Management Process
www2.unescobkk.org/elib/publications/myanmar1/chapter3.pdf
Most soft wood species are not termite resistant, and the hardwoods that are not attacked by insects are difficult to work with hand tools. All woods found at village level are unseasoned. Furthermore, the rough assembly techniques, used for building components, split and break the small wood pieces used in furniture. Finally, though mediocre quality glue is available; the artisans are not accustomed to its use. At township headquarters, one finds one or two cabinetmaker shops accustomed to assembling small components and using glue. However, power tools are few and power supply is irregular. Thus, they rely on hand tools that cannot achieve the needed close tolerances. To compensate for poor workmanship (and the use of green timber that shrinks after assembly) joints are nailed. The soft steel nails are of a diameter so large that they often split the tennons. Finally, each of these furniture makers' production capacities is on the order of 100 pieces per month when the project required 15,000 pieces to be produced and delivered in a 6-month period.
The following Figure is on page 23 of the report:

Figure 10: **Information flows and decision making for furniture**



3. Considerations – construction

Considerations in the Design and Development of School Furniture for Developing Regions Based on Local Resources

Carl Eckelman, Eva Haviarova, Hui Zui and Harry Gibson, *Forest Products Society* 51: 6, June, 2001

www.freepatentsonline.com/article/Forest-Products-Journal/76559707.html

In many, if not most, of the underdeveloped and developing countries of the world, school furniture is poorly designed, of low quality, and often unfit for school use, yet it is costly and consumes a disproportionate share of limited educational budgets. This situation need not continue. This research indicates that attractive, well-designed, durable, maintenance-free furniture can be produced from locally available woody materials, including plantation thinnings and semi-processed materials such as pallet deckboards, by local industry. Only the simplest machining and joinery processes are required to construct the furniture. Cost of the furniture is generally less than that of competing products, yet performance tests indicate that the furniture produced is very durable. Thus, attractive, sturdy, easily maintained furniture can be produced from local woody materials at a modest cost in any developing country.

School chairs for developing countries: designing for strength and durability, simplicity, and ease of construction

C.A. Eckelman, Y.Z. Erdil and E.Haviarova, *Forest Products Society* 53: 2, Feb, 2003

www.freepatentsonline.com/article/Forest-Products-Journal/98576645.html

Persistent shortages of school furniture pose serious educational problems in underdeveloped and developing countries. Research has shown that strong durable school furniture can be produced with simple tools and production processes. Thus, the opportunity exists to solve school furniture problems by utilising participatory cottage industry at the local level as well as larger manufacturers at the regional or country level. To do so, however, it is necessary to have designs that inherently ensure long maintenance-free service life, using parts that are easy to manufacture and constructions that are easy to assemble. This paper describes a design for school chairs, based on proven round mortise and tenon construction, which is not only strong and durable, but also easy to assemble and manufacture.

Performance tests of school chairs constructed with round mortise and tenon joints

C.A. Eckelman and E.Haviarova, *Forest Products Society* 56: 3, March, 2006

www.freepatentsonline.com/article/Forest-Products-Journal/144298804.html

Tests were conducted to compare the performance characteristics of school chairs constructed with pinned but unglued round mortise and tenon joints with those of chairs with glued but unpinned joints. Chairs with 0.125-inch cross pins in 0.723-inch diameter tenons developed over 90 percent of the strength of the chairs with glued tenons, whereas chairs with 0.313-inch diameter pins developed only 80 percent. Thus, results of the tests tend to indicate that chairs constructed with round mortise and tenon joints with small cross pins should provide nearly the strength and durability of comparable chairs constructed with glued joints, and therefore cross-pinning could be considered as an alternative method of joint construction in areas of the world where adhesives are in short supply.

Development of a manufacturing system for construction of school furniture
Harry Quesada and Rado Gazo, *Forest Products Society* 53: 9, Sept, 2003
www.freepatentsonline.com/article/Forest-Products-Journal/109404601.html
In order to address the school furniture problems that many underdeveloped countries face, Purdue University, in conjunction with the Institute of Technology of Costa Rica, previously developed a system for school furniture that is durable, strong, uses local small-diameter materials, and simple manufacturing techniques. The objective of this study was to develop a manufacturing system for construction of school furniture (chairs and desks) at both low capital investment and minimum cycle times. A pilot shop was successfully operated in Costa Rica to produce 50 school furniture sets.

Results of this model validation include: economic feasibility of the proposed system configuration, establishment of equipment layout, and collection of related process information. The project was divided into four stages: Product design, process design, implementation, and process control. The proposed manufacturing system was also validated. The construction of 50 furniture sets was performed, which required 276.8 board feet (BF) of parts from a total of 472.4 BF of raw gmelina lumber, resulting in a yield of 58.6%. Information about process time was gathered and analysed. The cycle time for a batch of 50 sets was 6.5 days (8-hour shift), the material product cost was $23.45/set ($13.99 for the desk and $9.46 for the chair), and the annual capacity for this pilot shop was 2,259 sets. Another important result showed that the capital investment for a shop like this is $11,426 with a payback period of 18 months. Software was designed to monitor process control activities such as production scheduling, inventory control, employee database, and quality control.

Design and construction of wooden school furniture for children in developing countries (Central America)
Eva Haviarova and Carl Eckelman, Purdue University, 2000
http://docs.lib.purdue.edu/dissertations/AAI3018208/
Although well-designed school furniture has been shown to contribute to children's learning process, school furniture used in developing countries often detracts from rather than facilitates education. Often, the furniture is of low quality, has rough writing surfaces, falls apart quickly, and does not fit the children, yet it is relatively costly and consumes a disproportionate amount of limited educational budgets. The purpose of this thesis is to address school furniture problems using a multidisciplinary approach combining design, product engineering, and material engineering to create furniture that is ergonomically correct, strong and durable, low in cost, requires little maintenance, and can be made by local industries from largely residue materials. The intent of the actual research was to design, construct, and evaluate one or more types of chair and desk constructions that would satisfy the previous criteria. Two types of construction were selected, namely solid wood construction and cross-lap laminated construction. Results of the research indicate that attractive, well-designed, durable furniture can be produced from locally available woody residues, mainly plantation thinnings, using only the simplest machining and joinery processes. Production techniques may vary from those best-suited to cottage industries to those more appropriate for small factories in more developed areas. Thus, school furniture and the accompanying production processes can be matched to the level of development of essentially any targeted country. Furthermore, neither the processes nor the materials involved in the construction of the frames are inherently costly. Thus, schools should be able to obtain durable, affordable, often locally-made furniture in essentially any region of the world.

Differences in construction, facilities, equipment and academic achievement among Ugandan primary schools
Stephen P. Heyneman, *International Review of Education* 23: 1, 35-46, 1976
www.springerlink.com/content/g76g16r1006204n5/

4. Durability

Characteristics of Classroom Chairs and Desks in Use in Senior Secondary Schools in Ibadan, Oyo State, Nigeria
A. Adéwolé and A.O. Olorunnisola, *Journal of Emerging Trends in Engineering and Applied Sciences* 1: 2, 140-144, 2010
http://jeteas.scholarlinkresearch.org/articles/Characteristics%20of%20Classroom%20Chairs%20and%20Desks%20In%20Use%20in%20Senior%20Secondary%20Schools%20in%20Ibadan,%20Oyo%20State,%20Nigeria.pdf
The current status of wooden classroom chairs and desks in use in selected Secondary Schools (SS) in Ibadan was investigated. Fifty-four SS were randomly selected; 12 each from rural and semi-urban, and, 10 from urban areas of Ibadan. Random sampling survey was conducted using structured questionnaire and oral interview and to collect data on chairs and desks types, designs, construction materials and methods, durability and cost factors. Joint features, failure pattern and causes were evaluated via on-the-spot assessments. Simple descriptive statistical tool was used for data analyses. Similar furniture geometry, constructional method and failure mode were noted in rural, semi-urban and urban schools. About 90% of the schools were using wooden chairs and desks. The two predominant designs were the Single-User (SU), and Multiple-User (MU) types. The production philosophy for both furniture types was one-size-fit all. The SU and MU chairs and desks had a relatively short service life with over 80% of them failing within three months. Poor jointing was responsible for over 69% of the failure. As at December 2009, a pair of SU and MU chairs and desks cost N2500 and N3500 respectively.

Construction Manual for School Furniture Based on Local Wood Resources
Carl A Eckelman, Purdue University
www.agriculture.purdue.edu/fnr/faculty/Eckelman/documents/sfchap01.pdf
Low cost, durable, attractive school furniture can be produced in essentially any region of the world from locally available wood, wood residues, or semi-processed woody materials. Only the simplest machining and joinery processes are required so that production techniques may vary from those best suited to cottage industries to those more appropriate for small conventional factories. Durability is guaranteed by structural design and construction techniques.

Details are given in this manual for the construction of several designs suited for schoolroom use. The construction techniques presented in this manual are not limited to these designs, however. Rather they can be applied to a wide variety of designs so long as the basic principles presented are followed.

5. Other Useful Resources

School Resources and Educational Outcomes in Developing Countries: A Review of the Literature from 1990 to 2010
Paul Glewwe, Eric A. Hanushek, Sarah Humpage and Renato Ravina, September 2011
http://faculty.apec.umn.edu/pglewwe/documents/Edinput7.pdf
The estimated impacts on time in school and learning of most school and teacher characteristics are statistically insignificant, especially when the evidence is limited to the "high quality" studies. The few variables that do have significant effects – e.g. availability of desks, teacher knowledge of the subjects they teach, and teacher absence – are not particularly surprising and thus provide little guidance for future policies and programmes.

School management and effectiveness in developing countries: The post-bureaucratic school
http://books.google.co.uk/books?hl=en&lr=&id=4XqaCGu5KpgC&oi=fnd&pg=PP5&dq=wooden+school+chairs&ots=MBr46DOEEy&sig=cm7JVso7F0w7xWYex8EeJjg4BdI#v=onepage&q&f=false
... A study in India found that 61 per cent of schools do not have enough blackboards, 49 per cent do not have enough maps and charts, and 49 per cent do not have any desks and chairs for students (Singhal, 1988). The maintenance of school buildings is often the first to suffer in ...

SACMEQ School Inputs Research
www.sacmeq.org/School-Inputs-research.html
Policy briefs by country, including Tanzania. And this paper includes numbers of seating resources:
SACMEQ Working Document nr. 2: Levels and Trends in School Resources
www.sacmeq.org/downloads/sacmeqIII/Levels_and_Trends_in_School_Resources_FIN2.pdf

TutuDesk Campaign
www.tutudesk.org/Home/tabid/41/Default.aspx
Since 2004, over 1 million portable writing surfaces have been provided across twenty countries in Africa. A further 20 million 'TutuDesks' are planned for the next 5 years to improve learning conditions for children.

ERGONOMICS – There are quite a few studies on the ergonomics and anthropometrics. And health issues like back pain and general demotivation because of height and shape. A couple of examples are included here:

Are the desks and chairs at school appropriate?
L. Saarni, C. H. Nygård, A. Kaukiainen and A. Rimpelä, *Ergonomics* 50 (10), 2007
www.tandfonline.com/doi/abs/10.1080/00140130701587368
The aim of this study from Finland was to find out how the measurements of chairs and desks match with the anthropometrics of schoolchildren and how schoolchildren sit during a lesson in their classroom. The results indicate that there is a mismatch between school furniture and the anthropometrics of schoolchildren. Schoolchildren sit in disadvantaged postures for a substantial part of school lessons.

The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour

Steven J. Linton, Anna-Lisa Hellsing, Tanja Halme, Kerstin Åkerstedt, *Applied Ergonomics* 25 (5), pages 299-304, October 1994
www.sciencedirect.com/science/article/pii/0003687094900442
This study tested the effects of implementing ergonomically designed school furniture on measures of comfort, sitting posture and symptoms. Three classes of fourth graders (10 years old) were randomly assigned either to a control group using traditional furniture or to an experimental group which received the ergonomically designed furniture. In both groups questionnaires were completed and sitting behaviour was observed twice before and after the intervention as well as at a five-month follow-up period. Although the experimental groups rated their furniture as being significantly more comfortable, differences in actual sitting behaviour were small. The experimental class experienced a reduction in musculoskeletal symptoms relative to the control group after implementing the ergonomically designed furniture. Since pupils did not automatically sit 'properly' in the ergonomic furniture, these results demonstrate the need for proper instructions and adjustment. Increased comfort and decreased symptoms may be used to motivate pupils to sit correctly. Results suggest that furniture design is one aspect of a multidimensional problem.

6. Additional Information

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