

Indigenous African Artefacts: Can they Serve as Tangible Programming Objects?

Andrew Cyrus SMITH¹, Paula KOTZÉ²

^{1,2} CSIR Meraka Institute, PO Box 395, Pretoria, 0001, South Africa

²School of ICT, Nelson Mandela University, Port Elizabeth

¹Tel: +27 12 8414626, Fax: + 27 12 8414720, Email: acsmith at csir.co.za

²Tel: +27 12 8414791, Fax: +27 12 8414720, Email: paula.kotze at csir.co.za

Abstract: In this paper we are interested in determining if there is indeed an opportunity to use existing traditional African artefacts as tangible programming elements in computing systems. Research to date has focussed on the design of new artefacts for use in tangible environments. These artefacts are based on Western perceptions. Prior research has also shown that, when introducing new concepts to a developing region, as much of the local content as possible should be incorporated into the new technology. It would therefore be prudent to investigate which dimensions of African artefacts can be exploited when developing tangible interfaces for rural Africa. In this paper we report on the results of a preliminary literature review aimed at identifying possible usable aspects of African artefacts as they pertain to tangible programming environments. A proposed tangible programming environment is given.

Keywords: Tangible programming, Computer interaction, African artefacts, Interaction design.

1. Introduction

The aim of our research is to investigate the possible use of physical artefacts as tangible programming objects with the purpose of instilling an interest in programming amongst regional tribes in Africa. Physical artefacts are hand-crafted objects made by community members. We envisage a simple computing system that derives its input from the manipulation of artefacts as opposed to the use of a keyboard and mouse. In order to do so it is advisable to make use of artefacts and colours familiar to the target group. Care should be taken to align with the local customs or beliefs when incorporating elements of these into a system which is based on the artefacts [1].

The use of icons and symbolism is not new in human-computer interaction research [2]. It is well known that metaphors can be used as a basis for developing tangible computer interfaces.

Learning computer programming can be compared to traditional fine art education. With the latter the student progresses through mastering the technique of drawing through composition and then art [3]. The student is not exposed to all concepts at the same time, but rather taken step-by-step by first mastering a single concept. Once that has been done the next concept is mastered, incorporating prior learning. Similarly, the novice computer programmer should be assisted in the learning experience by structuring the learning to first deal with logical thinking processes, using materials and environments familiar to the student. Once the logical thinking process has been mastered, the underlying computing technology can be introduced.

This paper investigates attributes of African artefacts that can possibly be used in the creation of a tangible computing environment aimed at the computer novice in rural Africa. Our hope is that this research will form the basis on which future technology will be developed.

Section 2 of this paper provides a brief overview of related research on abstract objects and aspects of African cultures. Section 3 describes the research method followed, while section 4 discusses our findings, highlighting aspects of African cultures that can be applied to computer programming. Section 5 proposes a programming environment which exploits these findings and section 6 discusses proposed future work. Section 7 concludes.

2. Background

A number of factors should be taken into account when a technological intervention is considered, independent of the region being targeted. Three such factors are: the financial sustainability of the intervention, sensitivity to local traditions, and any additional burden placed on the intended beneficiaries.

When contemplating the introduction of computer programming in a developing region, one of the burdens to consider is that of the additional cognitive effort required to accomplish the same task usually achieved through manual labour. Considering the cognitive burden that each of textual-, graphical-, and tangible- computer interfaces presents to the user, that of the tangible interface seems to be the lowest (Figure 1) and thus probably best suited for the introduction of computing technology to developing regions.

This section introduces abstract tangible objects and how it relates to the African context. It concludes with a recommendation on integrating African objects with programming.

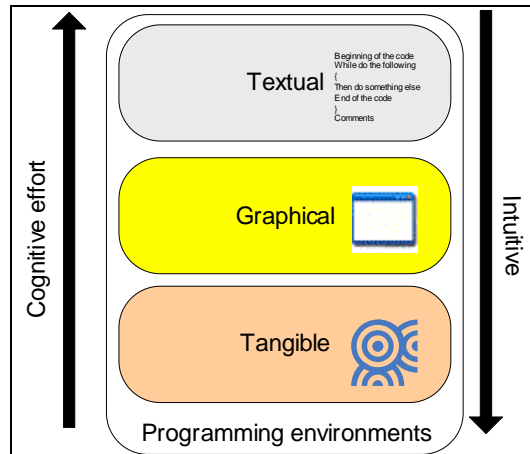


Figure 1: The Relative Cognitive Effort Required when Using Various Programming Environments [6].

2.1 Abstract Tangible Objects

Heijboer and van den Hoven conducted a study to determine to what level a physical artefact can be abstracted and still be interpreted correctly in the context for which it was designed [4]. They concluded that very few identifying elements in the artefact (Figure 2) were actually required for correct interpretation. The aim of the study was to develop tangible board game objects which would interact with underlying electronic systems. This study was conducted at a science club in Atlanta, USA. These findings have yet to be confirmed for regional tribes in Africa.

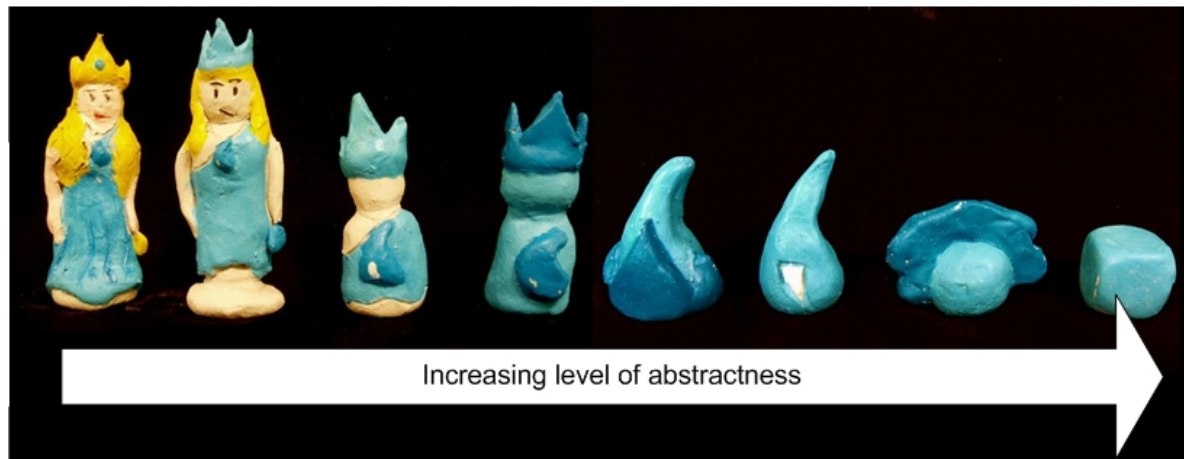


Figure 2: Determining which elements are important in physical artefacts [adapted from 4].

2.2 Tangible Objects in the African Context

Central to the discussion in this paper is the concept that the meaning of traditionally crafted objects does not reside in the object itself, but rather the meaning the user associates with the object [French philosopher Roland Barthes as referenced by [5]]. We next discuss how the local population in Africa craft their own artefacts, embedded with meaning significant to its creator.

2.2.1 Region-Appropriate Artefacts

When considering which artefact to use as a tangible interface, it would be prudent to choose those that are traditional and have meaning for the local population. Not all African crafts are traditional or contain a message. Most crafts to be found at markets and shops are purposefully made for the tourist, often artificially aged to increase its monetary value.

This can be explained as follows: To most Africans a new object has the most spiritual power, and it is for this reason that when a new artefact is offered on the market it was probably made, not for actual use but, for the tourist. The tourist attaches more value to an object which has actually been used and would prefer to purchase a thoroughly used artefact. Those who supply the tourism market have become aware of this need for used artefacts and therefore artificially ‘age’ the product to make it look used. In contrast the African owner attaches more value to a new artefact which has more spiritual power and would prefer to part with the old object in return for the new [7].

2.2.2 ‘Hidden’ Messages

Other factors to be considered when evaluating artefacts’ suitability as tangible interfaces are colour and patterns. The researcher should beware that the patterns and colours incorporated would often be misleading, containing no value other than for artistic reasons. The researcher should not strive to ‘discover’ a traditional message. In other words, these artefacts are of little value when trying to make a connection between traditional artefacts and modern computing systems as is the case with the current research. A significant number of African artefacts are purposefully crafted for the tourist market. The tourist often comes across miniature carvings of elephants and antelopes, lions, reptiles and birds. These are examples of artefacts created for the benefit of the tourist and are not traditional [8]. The researcher can therefore not expect to find many traditional artefacts in tourist traps, those found there already incorporate European influence. Those artefacts that have been adapted for the tourist market would be inappropriate as traditional African computer

interfaces. This is because the local community would not recognise the foreign attributes contained in the artefact resulting in the incorrect use thereof.

2.2.3 African children are cRafters

The children of Africa design and craft sophisticated hand-made artefacts such as wire cars [9][10]. An example of an intricate rack-and-pinion steering mechanism constructed by African children is shown in Figure 1. In this example the child makes use of discarded materials such as soft iron wire, copper wire usually used by the national telecommunications operator, shoe polish cans, and soft drink tins. As tools, the crafter uses large stones to straighten the wire before bending it into the required shape with the aid of a pair of pliers [9]. Figure 3 (right) is an example of a completed wire car in use. Clay is another material traditionally used for moulding figurines of cattle and other objects familiar to the crafter [10]. The appearance of these objects varies from realistic to abstract.

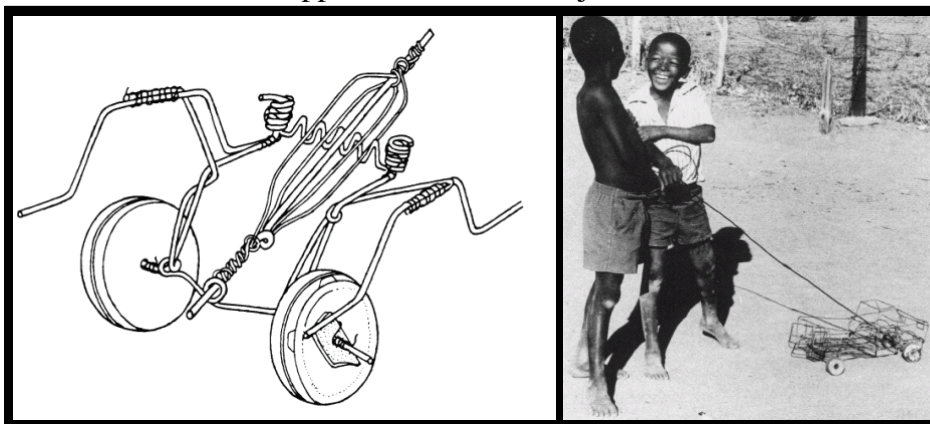


Figure 3: Intricate mechanisms constructed by African children [9].

2.2.4 Beadwork

Beadwork is used as a form of adornment to signify social roles and identities across most cultures in Southern Africa. Tradition prescribes the dress and adornment, which coincidentally may be modified using modern and commercial materials such as plastic beads and safety pins. The use of patterns and bead colours used by Zulu girls vary according to the region [11].

2.2.5 Intervention with Sensitivity

Consider Zulu beadwork which reflects their society where social, religion, education, recreation, politics and more, are mutually supportive. This makes for a strong system that is resistant to change. This resistance to change can be detrimental to the society as it will resist change until it can no longer withstand it. At that point serious socio-economic damage will occur. But developmental programmes usually require the introduction of new concepts to a society. It is therefore important to introduce new technologies in a manner which is sensitive to current customs in the society and to respect these [12].

2.3 African Objects are Abstract Interfaces?

From the above it is evident that the peoples of Africa are competent in creating hand-crafted artefacts. From early childhood to adulthood, its people are involved in adding meaning to the raw materials they manipulate. The meaning of an artefact is 'in the eye of

its creator' and not documented, yet it could be possible to design a system which makes use of these very personalised objects as interfaces to modern technology.

As far as the authors could ascertain, no prior work by others exist which investigates the use of African artefacts as technology interfaces.

3. Research Method

The ethnic groups included in the large continent of Africa are numerous, too many to be covered in this or any other single research paper. Societies in Africa vary and a 'traditional' African society does not exist. For this reason we limit discussion mostly to groups found in Southern Africa.

A literature review of both African artefacts and tangible computer interfaces provided the source material for this research. The identified literature on African artefacts was then subjected to textual analysis. This analysis was used to extract the usage of the artefacts, as well as certain attributes which the community appropriates to the artefacts. The results were captured in a table and certain entries identified and subsequently used as input to the synthesis of a proposed programming environment. This programming environment is elaborated on elsewhere in this paper.

4. Findings

Our research into African artefacts has revealed that some customs and artefacts, exhibiting certain properties, can potentially be incorporated into a programming environment suitable for rural Africans. The following paragraphs highlight some of these findings from the Zulu, Ndebele, and Swazi cultures.

4.1 Appropriate Metaphors

Metaphors in widespread computer use are not always appropriate. An example is a cardboard folder that is used to contain a collection of related paper documents. In the world of computers, an on-screen icon serves the same purpose for electronic information. Such icons are incorporated into most current GUIs and are based on Western perceptions which are foreign to the rural African. If a GUI for rural Africans was to be developed, it would be prudent to either use current metaphors already in use in the local community (the concept of 'cultural residency' [13]), or develop new metaphors in consultation with the local population [14].

4.2 Local Solutions

In general, Western societies have become accustomed to purchasing the artefacts required for day-to-day living. Examples are a desktop computer for keeping track of investments, plastic toys for babies, plastic containers for storing food, a plastic toothbrush for brushing teeth, and an oven for preparing food. In contrast, the rural African population can do without these commercial products, crafting their own solutions from natural materials available in their environment. Example of solutions fashioned by the end user are rocks in the hut to keep count of cattle owned, a clay antelope baby toy, a clay pot for storing food, a twig and fire ash for brushing teeth, and a hollowed-out ant nest for preparing food.

4.3 Patterns

In Africa the shape of an object, or the pattern embedded in it, has significance. An example is the use of a decorated animal skin traditionally worn by a Zulu man to cover his buttocks (Figure 4). The skin is embellished with semi-circular patterns, signifying that the

wearer “is looking for a girl”. The prominence of the semi-circular patterns in the second example (middle) is diminished, being of an old, married man. This apron was made by his wife to indicate that he was still very virile. On the right is an apron of a married man who is living at home. Simple and subdued ornamentation is used because, in the words of its owner, “you don’t have to court”.

The display of bright and large patterns in the example above reminds one of those encountered in nature, typically amongst male birds where large colourful feathered surfaces are displayed when courting.

This “geometry of information” is also contained in African beadwork, basketry and ceramics. Both men and woman make use of beads to convey messages. However, the beadwork worn is specific to the gender [15].

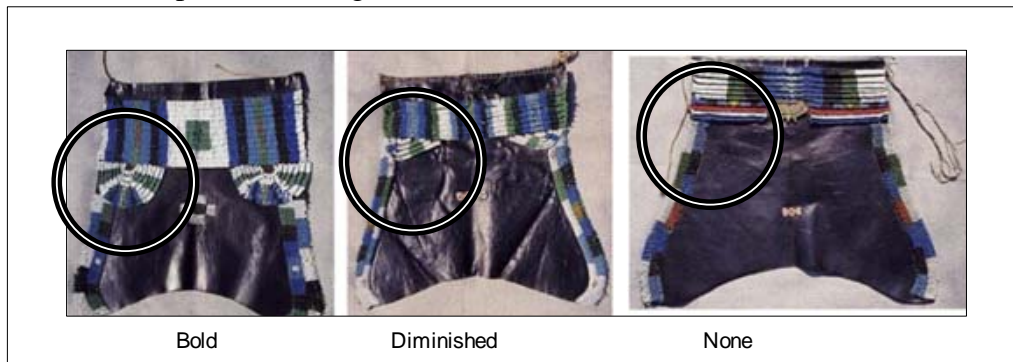


Figure 4. Messages conveyed by three buttocks-covering skins (*iBheshu*). Adapted from [12].

4.4 Dolls

In Africa, ‘dolls’ are not toys but serve as objects for teaching and entertaining. Ndebele and Zulu dolls are considered next.

4.4.1 Ndebele dolls

The beadwork on the Ndebele dolls closely resembles the clothing an Ndebele woman would wear [16]. A childless woman in Southern Africa’s Sotho, Ndebele and Zulu groups carries a beaded doll to ‘cause’ pregnancy [15]. The Ndebele call this a *fertility* doll. When assembling a collection of tangible interfaces, the researcher can thus use an Ndebele doll to depict a woman.

Ndebele dolls are colourful and make for popular gifts amongst tourists. To the tangible interface researcher there are some important distinctions to note. Characteristics that distinguish the Ndebele dolls (Figure 5, left) are as follows: (1) the *Initiation* doll has a long vertical bead design representing tears for having “lost” a son due to an initiation ritual [16]. The tears can also be attributed to the mother’s sympathy for the hardships her son will experience during the ritual [17]; (2) the *Bride* doll is characterised by the veil, the beaded train and the panelled skirt. Each panel represent a head of cattle her family will receive as payment; (3) the apron of the *Mother* doll indicates that her child was born in wedlock. More specifically, a married woman with children can be identified by patterns of alternating red and black beads. A blue-and-black bead combination indicates that she was a virgin when married [18]; (4) finally, a beaded hoop and the style of the apron distinguish the maiden who is engaged to be married [16]. The uncovered arms of the maiden reinforces her status as an unmarried girl [17].

4.4.2 Zulu dolls

Zulu dolls also convey messages. A girl engaged to be married would make a doll (Figure 5, right) and wear it around her neck. When in the presence of her future in-laws, the girl would cover the doll's eyes with its hair as a sign of respect. Once married, a piece of red wool would be placed on the head and the doll kept in a special place in the home [19].

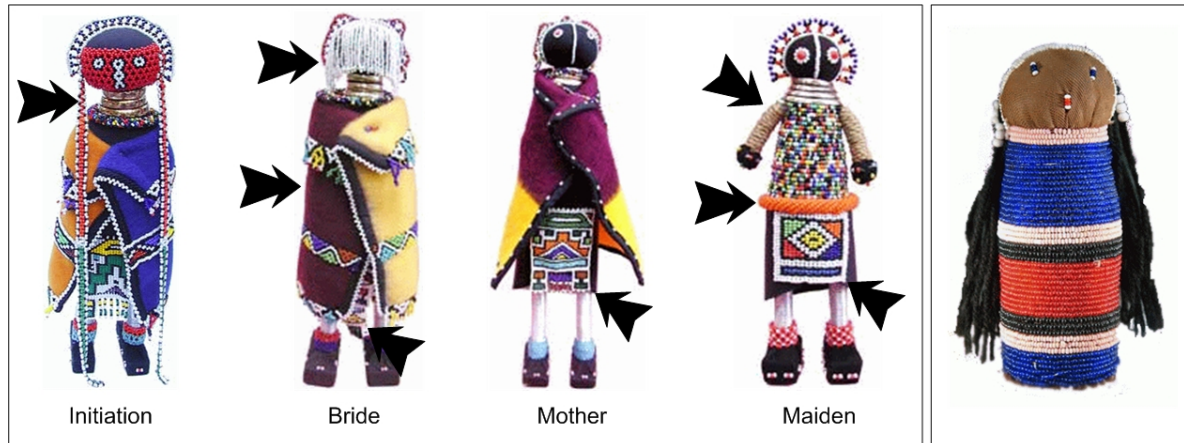


Figure 5: Left - Four Ndebele dolls [16] with distinguishing characteristics highlighted. Right- Zulu fertility doll [19].

4.5 The Concept of Time

To the Ndebele, various naturally occurring events and objects mark the seasons. For example, swallows indicate a rainy season, the shooting of trees indicate the ploughing season. The coming of summer has many indicators: a dashing-star, a sky turns red at sunset, the North Easterlies blowing hard, frogs croaking, and crickets screeching [1].

4.6 Other Findings

Certain concepts are also conveyed through colours. For example in the Zulu culture, a man wearing a string of black beads indicates that he has rejected his lover. Examples of the use of colour in the Swazi culture are: blue represents the sky; a combination of black and white represents racial harmony; and yellow represents the country's mineral wealth. Red signifies fertile soil [20].

Beads have the following meanings in the Zulu culture: a wife who does not wear any beads indicates that she is now a widow; beaded arrangements of green and black indicate that a girl wants her lover to inform her of their marriage date; a one-dimensional bead arrangement with a puff-adder snake pattern signifies a female; and a beaded animal skin worn as an apron protects the unborn child [15].

Colours and patterns only have significance within the local community where it was created. This is because no written form is used to capture their meaning; only verbal transmission is used for sharing knowledge. This makes it possible for people from outside the community, with no local community knowledge, to misinterpret the symbols.

Messages conveyed through patterns and colour range from simple and easy-to-interpret ones, to messages targeted at an individual and encoded in such a way that others (rivals or parents) in the community are unable to recognise it.

Beading and patterns also provide a voice to women who are usually expected to remain silent over certain issues.

In some instances the pattern and colours of an artefact do not play a significant role. A case in point is when there is another, more dominant, message already contained in the

article. An example is a colourful waistband worn by a woman. Here the message conveyed is that the woman is married, as evident by the waistband [18]. The observer need not interpret the patterns and colour further.

Additional interesting examples [21] of artefacts and their significance are given in Table 1.

Table 1: African Artefacts and Their Significance.

Artefact	Significance
A grinding stone/copper bangles	The passing of time
Pot/water	Femininity
Spear/rod	Masculinity
Staff	A boy
Calabash	A Girl
House spider	Good omen [1]

5. Tangible User Interfaces and Programming

We next relate our findings to the task of programming computing technology. The use of African artefacts, to either replace or compliment existing two-dimensional interfaces such as computer keyboard and mouse, is a new research domain which holds great promise. The next two subsections touch on the meaning of physical objects as it relates to programming and gives an example of a possible programming environment using African artefacts.

5.1 Materiality of Tangible Programming Elements

Materiality describes the physical properties of the tangible object. The intended audience should be taken into account when physical properties are considered [5]. In the case of novice programming, the audience would be the rural South African. An example of such a group is the Zulu. To address this group it would be prudent to make use of materials well-known to them, embedded with meaning which have withstood oral transmission across generations. Meaning is communicated through the physical properties of the artefact, the colours, and other visual codes [5]. As in the fine arts, the colour and shape have significance central to the understanding of the object itself. Without these elements the meaning is lost.

5.2 Tangible Programming Example

The use of tangible objects that serve as interfaces to computing environments is a young research field and relies on the innate ability of the user to identify appropriate properties of the artefact used. This section provides three examples of how the findings above can be exploited by incorporating them into tangible interfaces. In all examples some form of as-yet to be developed technology will capture the status of the objects and their relative positions. The design of this technology will be the subject of another paper.

(1) The first example is the use of the Ndebele doll to indicate the status of an ‘actor’ in a computing system. If we assume that the system has been designed to take inputs from the actor, then by changing the attire and other properties of the doll the user can influence the behaviour of the system. For instance, a young girl may tell a story by playing with a doll. Various items of clothing are added to the doll as the story progresses. This data is captured by the underlying sensing technology and can be enacted by software at a later stage.

(2) A second example makes use of seasonal indicators to represent time. If a system is designed to execute certain functions based on time, the user can manipulate the system by

using objects such as swallows, trees, frogs and crickets. To the Ndebele each of these objects represents a different point in time.

(3) The third example illustrates how a simple tangible programme can be “constructed” (Figure 6). In this example it is envisaged that a story will be enacted on the computer using either animated characters or video clips (Figure 7). The storyline is programmed using the Zulu dolls shown by placing them at predetermined positions on a shelf.

In the hypothetical example given, instructions are executed from top-left to bottom-right. Each instruction influences the execution of the programme.

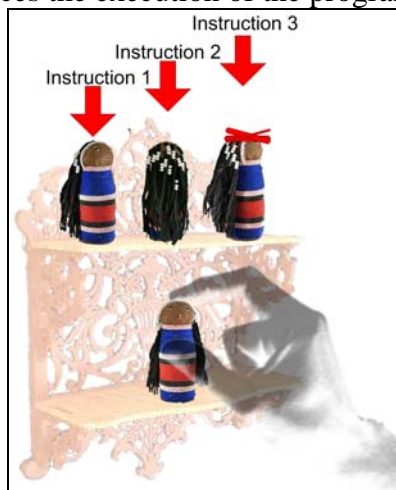


Figure 6: The Envisaged Programming Environment.

The storyline programmed is that of a young rural girl. The first decision the programmer makes is whether the girl continues with her rural life, or moves to the city. This decision is made using Instruction 1. Should the programmer decide to let the story continue in the rural area, the story continues with the girl enjoying the company of her peers until such time as when she meets an unmarried man. At this junction the programmer decides whether the girl should accept his approach. If she rejects him, the young man decides to leave the tribe and the story ends. In this example the programmer has chosen to accept the advance by covering the doll’s face with the hair (In the Zulu culture this action indicates that the girl is in the presence of the future in-laws). Now the young man’s family negotiates *lebola* (dowry) with the maiden’s family. Here is another decision the programmer has to make. If the programmer decides that the negotiations were successful, the story ends with the girl bearing a child in wedlock.

Figure 7 illustrates three alternative endings to the storyline based on the instructions given at decision points in the execution of the programme.

Once the system has been implemented, the dolls will contain embedded electronic circuitry, and the shelf will contain sensing circuitry. The combination of these augmented objects senses the relative positions and configuration of each object. This data is transferred to a receiver that executes the programme constructed. A computer is an example of such a receiver. This enables a non-literate (not able to read or write) person to “construct” a simple programme for execution.

6. Future work

The issue of timing, telling time, and leaving a message about time has not been covered in this paper. In general, computing relies on timing to co-ordinate actions. Perhaps a candle could be used to represent time, such as was used by the Boers in Southern Africa. Another means of conveying the passage of time, much less precise and with lower resolution, is the use of natural signs. The passage of the sun and moon are examples. During the day, the

length of shadows is used by rural populations as a time indicator. For even longer timing, the change of seasons is used. Here fruit and leaves on trees serve as indicators.

Other artefacts not discussed here are those typically classified as masks. These are available in many forms. Examples are ‘cap’, ‘helmet’ and ‘full body’ [22]. However, these objects play a lesser role in Southern Africa.

Significant work is still required to test the viability of the concept presented in this paper. First, a concept demonstrator will have to be built and evaluated in the laboratory. Lessons learnt will then be incorporated and formal tests conducted in rural areas. We anticipate that a number of test-improvement cycles will be required before a useful system emerges.

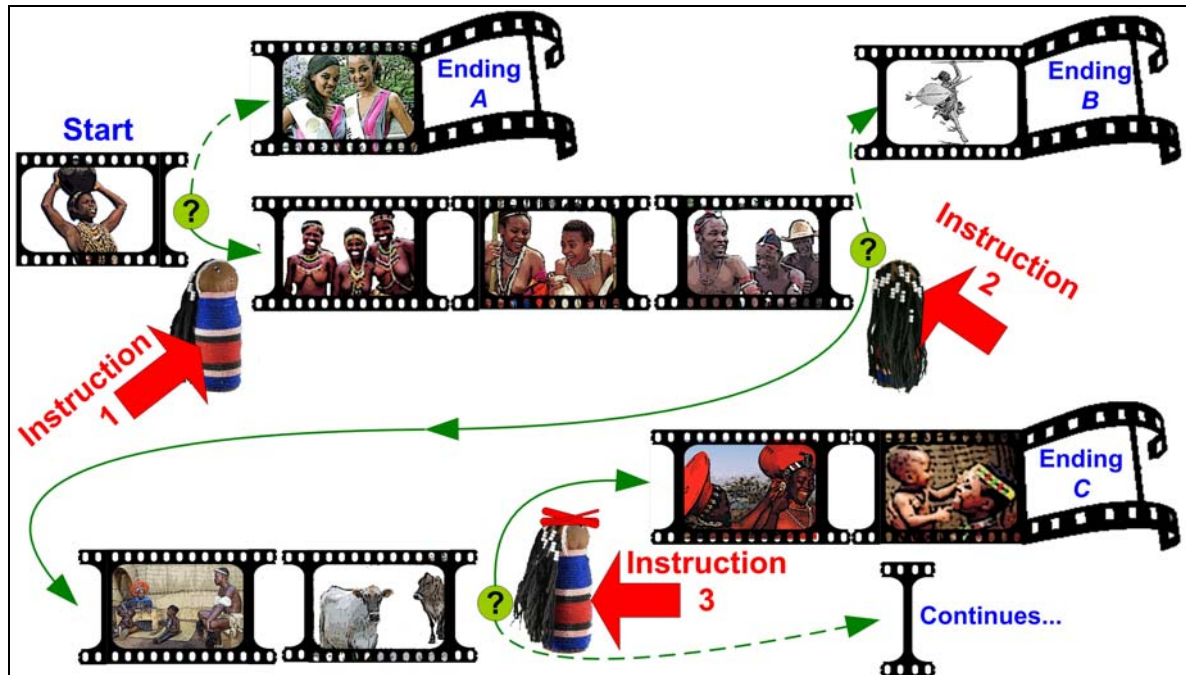


Figure 7: A story encoded by three instructions.

7. Conclusion

In our quest for a useable mapping between African art and tangible computer interfaces, we discovered that African craft is rich in meaning. Traditional Africa has a rich system of communication, using artefacts and symbols which are embedded within these artefacts. It is also evident that interpretation of the artefacts is not trivial and requires knowledge of the community in which the artefact was made. Without this background, the meaning of the artefact remains a mystery. From our limited personal interactions with urban Africans it appears that the artefacts have already lost some of their meaning. A study is needed to determine what knowledge urban Africans still retain of traditional artefacts and symbols.

Certain African societies (the Ndebele, for example) prefer the simple rural life of farming as opposed to the fast city life [1]. For this reason, if these societies were to be introduced to modern technology, it would be better to reach them in the rural areas, using metaphors and materials they are familiar with.

We have demonstrated through references to prior research that rural Africans are capable of designing and crafting sophisticated mobile-, as well as abstract- objects that can potentially be incorporated into computer interfaces. In conclusion, the development of useful tangible computer interface elements, based on indigenous African artefacts, looks promising.

Acknowledgments

Mncedisi Bembe and Nokwazi Ndlovu assisted with information on Swazi attire. Dr Nomusa Dlodlo and Promise Mvelase provided assistance relating to the Zulu and Nguni cultures in general. This research was funded by the South African Department of Science and Technology.

References

- [1] W. Bozongwana, Common beliefs and signs of coming events, Mambo Press in Association with The Literature Bureau- 1983, as published at <http://www.inkundla.net/net/imbali/commonbeliefsandsigns.php>, Accessed 16 November 2009.
- [2] A. Marcus, Icons, symbols, and signs: visible languages to facilitate communication. *Interactions* 10, 3, 2003, 37-43.
- [3] B. Buxton, *Sketching user experiences: getting the design right and the right design*, Morgan Kaufmann, 2007.
- [4] M. Heijboer and E. van den Hoven, 2008. Keeping up appearances: interpretation of tangible artifact design. In *Proceedings of the 5th Nordic Conference on Human-Computer interaction: Building Bridges*, 2008. NordiCHI '08, vol. 358. ACM, New York, NY, 162-171.
- [5] I. Noble and R. Bestley, *Visual research: an introduction to research methodologies in graphic design*, AVA Publishing , 2005.
- [6] A. C. Smith, Hand-crafted programming objects and visual perception, *IST-Africa 2009 Conference Proceedings*, Paul Cunningham and Miriam Cunningham (Eds), IIMC International Information Management Corporation, 2009, ISBN: 978-1-905824-11-3.
- [7] D. J. Crowley, The Contemporary-Traditional Art Market in Africa Author(s):, *African Arts*, Vol. 4, No. 1 (Autumn, 1970), pp. 43-49+80 , UCLA James S. Coleman African Studies Center.
- [8] Kamba, <http://www.bluegecko.org/kenya/tribes/kamba/arts.htm>, Accessed 16 November 2009.
- [9] P. Davison, Wireworks: Toys from Southern Africa, In: *African Arts*, Vol. 16, No. 3 1983, pp. 50-52, UCLA James S. Coleman African Studies Center.
- [10] J. B. Derogowski, Wire toys in Africa South of the Sahara, In: *Leonardo*, Vol. 13, No. 3, 1980, pp. 207-208.
- [11] S. Klopper, *Dress and adornment*, Struik Publishers, 2001.
- [12] H. S. Schoeman, A brief historical review of traditional African beadwork in Africa, South of the Sahara, <http://www.marques.co.za/clients/zulu/history.htm>, Accessed 16 November 2009.
- [13] A. Botha, Personal discussion, 20 November 2009.
- [14] N. J. Bidwell and H. Winschiers-Theophilus, Beyond the Benjamins: toward an African interaction design, In *Interactions*, ACM Jan/Feb 2010, 32-35.
- [15] M. Carey, Gender in African beadwork: an overview, In L. D. Sciamia and J. B. Eicher (Eds), *Beads and Bead Makers: Gender, Material Culture and Meaning (Cross-Cultural Perspectives on Women)*, Berg Publishers, 1998.
- [16] Ndebele dolls, <http://www.thefolkartgallery.com/ndebeledolls.htm>, Accessed 13 November 2009.
- [17] S. Skosana, Personal discussion, 8 February 2010.
- [18] F. Jolles, Continuity and change in Zulu beadwork conventions: The interaction of color and pattern, In *Symmetry comes of age: the role of pattern in culture*, D. K. Washburn and D. W. Crow, University of Washington Press, 2004.
- [19] African dolls, <http://www.ezakwantu.com/Gallery African Dolls Fertility - Dolls.htm>, Accessed 10 February 2010.
- [20] N. Ndlovu, email correspondence with M. Bembe, 16 November 2009.
- [21] E. W. Smith, African Symbolism, In *The Journal of the Royal Anthropological Institute of Great Britain and Ireland*, Vol. 82, No. 1 (Jan. - Jun., 1952), pp. 13-37, Royal Anthropological Institute of Great Britain and Ireland, Accessed 11 November 2009.
- [22] D. Green, In *African dance: an artistic, historical, and philosophical inquiry*, K. Welsh-Asante, Africa World Press, 1994, p22.