Web-Based Learning Objects for Teaching Computer Studies in Secondary Schools

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Abstract

The use of ICTs to improve the access and affordability of education is perhaps the greatest unrealized promise of e-development, particularly in developing countries. This paper argues for blended learning in secondary school computer studies in which teachers can use digital resources to complement traditional teaching/learning methods to deliver computer studies lessons. The framework that we propose builds on the learning objects technology. We develop a sample of learning objects in computer studies that could potentially be stored and accessed by learners and teachers at senior secondary school level in Botswana. We argue that together with face-to-face learning, learning objects can be useful for both teachers and students in the teaching and learning of computer studies. The emphasis of the work is to incorporate instructional design theories in the design and use of the learning objects if they are to facilitate learning at the secondary school level.

Keywords: Learning Objects, Object-Oriented Paradigm, Instructional Design Theories, Blended Learning, E-development

1.1 Introduction

Web-based learning resources have the potential to support a learning environment in which students explore knowledge and enhance their learning. Learning objects, which are digital learning resources that can be used to support learning can be shared through the internet. Learning objects are seen as important in providing quality resources for teachers and learners. They can be re-used.

This work aims to design and develop learning objects from the control systems section of the Botswana General Certificate of Secondary Education (BGCSE) computer studies syllabus. The major users of the learning objects are school students under the guidance of the teacher. Pedagogical usability has crucial importance when designing learning objects for the secondary school curriculum, and therefore will be taken into account during the design and development of the learning objects. The context of employing learning objects differs between the sector and age of the intended user of the learning object. Haughey & Muirhead (2005) made the point that the use of learning objects varies depending on the age of the learner. In adult settings, learners can use the learning objects independently. In the secondary schools, learning objects have been designed for face-to-face classroom instruction, or to complement face-to-face instruction. According to Haughey & Muirhead (2005), learning objects are designed to help teachers perform functions like introducing new topics and skills, provide reinforcement to existing skills, illustrate concepts that are less easily explained through traditional teaching methods, support new types of learning opportunities not available in a classroom environment, and provide enrichment activities for gifted and highly motivated students.

Wiley and Edwards (2001) stated that the potential of reusable learning objects as an instructional technology is good, but will never be realized without a balanced effort in technology (technical specifications) and instructional design (learning specifications) areas. The lack of balanced effort between technical and learning specifications in online instructional and learning objects has not been widely considered for enhancing the online instructional design process or creating effective online reusable learning objects. McCormick (2003) argues that efforts to include a specific pedagogy are doomed to failure and advocates for the "development of LOs with sophisticated, high quality media representations of content, around which teachers build learning activities and assessment". While all these arguments are ongoing, there is a general agreement among the researchers that the use of learning objects impacts positively on the overall performance of the students and teachers in secondary schools (Haughey & Muirhead, 2005; Kay & Knaack, 2005; Churchill, 2006; Farrell, Glen and Shafika I. 2007).

The purpose of this study was to design and develop aesthetic learning objects for computer studies at the secondary school level. It is expected that the learning objects to be developed will help in the learning of computer studies by the student at the secondary school level. The learning objects to be developed will follow a taxonomy proposed by Churchill (2006) that classifies the learning objects into the following types: presentation, practice, simulation, conceptual models, information and contextual representation objects.

1.2   Conceptual Framework
Learning objects are commonly viewed as the smallest element of stand-alone information required for an individual to achieve an enabling performance objective or outcome. Learning object uses include, but are not limited to, online instruction or performance support. Grounded in the object-oriented paradigm from computer science, learning objects are central to instructional design theories offered by Merrill, Li, and Jones (1990), and Wiley (2000). These theories support breaking down content into constituent parts, then reassembling that content to meet specific learning goals.

Most of the current learning objects also incorporate a combination of some or all of the following media: audio, video, animations, graphics, text, and some type of user interaction (which might include text entry, drag and drop, multiple select, and/or button pushing).

1.2.1   What is a Learning Object?
When teachers first gain access to instructional materials, they often break the materials down into their constituent parts. They then reassemble these parts in ways that support their individual instructional goals. This suggests one reason why learning objects may provide instructional benefits: if instructors received instructional resources as individual components, this initial step of decomposition could be bypassed, potentially increasing the speed and efficiency of instructional development.

The Learning Technology Standards Committee (LTSC) chose the term "learning objects" to describe these small instructional components, established a working group, and provided a working definition:

Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. (LOM, 2000).

Different other groups outside the have created different terms that has narrowed the scope of the LTSC definition.

A learning object, for all practical purposes, is an object or set of resources that can be used for facilitating intended learning outcomes, and can be extracted and reused in other learning environments.

Better definitions result by considering the two related fundamental aspects of learning objects: the digital aspect and the educational purpose.

The following definitions and interpretations for learning objects have also been noted previously:

1. Any digital or non-digital entity for technology-supported learning (IEEE, 2001).
2. Any digital resource that can be reused to support learning (Wiley, 2000).
3. Any digital resource used to mediate learning (Wiley & Edwards, 2001).
4. A reusable digital resource built in a lesson (McGreal, 2004).
6. A content object with a pedagogical component (Clifford, 2002).

McGreal (2004) writes that, ''the reality lies in accepting the limitation that learning objects must be digital learning resources'' thus suggesting that the possibility that a learning object might be non-digital should be excluded (Churchill, 2006). Based on these interpretations, we will adopt the following definition:

A learning object is *any digital resource that can be reused to support learning."* (Wiley 2000)*.

This definition includes anything that can be delivered across the network on demand, be it large or small. Examples of learning objects include digital images , video or audio snippets, small bits of text, animations, and smaller web-delivered applications, like a Java applet and web pages that combine text, images and other media or applications.

The above definition captures what we feel to be the critical attributes of a learning object, "reusable," "digital," and "learning". The definition explicitly rejects non-digital and non-reusable resources.

1.2.2 Pedagogical Usability

From a technological point of view, learning objects use information technology resources as the delivery mode. They incorporate multimedia component such as animations, video, audio clips, images and text. These learning objects are embedded within a learning strategy, and are associated with pedagogical values that affect teaching and learning processes in school education. Web-based learning objects would support different topics from the computer studies syllabus. The added value of web-based learning resources (WBLRs) in terms of learning compared to teacher-and textbook-directed instruction lies in supporting the student to acquire knowledge through interactive, flexible, differentiated, and motivating activities (Hadjerrouit, 2010). The core of these learning objects is the integration of content, technology, and pedagogy into a system that supports learning. With other words, web-based learning resources exist at the intersection of content, pedagogy and technology (Hadjerrouit, 2010).

Pedagogical usability has been addressed by Nokelainen (2006), who defined a set of ten pedagogical usability criteria that can be applied to digital learning material, that is learner-control, learning activity, collaborative learning, goal orientation, applicability, added value, motivation, previous knowledge, flexibility and feedback. This criteria has been expanded to include understandability, time, multiple representation of information, autonomy, and variation. These criteria aim to support the learning process in secondary education.

1.2.3 User-Centred Design

User-centred design is an approach to software design that grounds the process in information about users through analysis, design, implementation, and evaluation of the software product (Hadjerrouit, 2010). It is centred on technical usability. Technical usability does not emphasize pedagogical usability, which is of crucial importance in school education. Developers of learning objects need to incorporate pedagogical considerations in the development process. This points to the importance of pedagogical usability in the design of the learning objects. The learning objects are used by school children under classroom conditions. Our design of the learning objects for the control systems will consider pedagogical usability. Technical usability is a self-evident requirement for the development of all information technology systems.

1.2.4 Learning Objects in Secondary Schools

According to Haughey & Muirhead (2005), the overall development of learning objects is still much of a rugged front. Much of this development in Australia, Canada, Europe and the US, has occurred in the post-secondary sector, mainly in universities and much of the research focuses on issues in an adult setting. The design and development of learning objects for the secondary schools differs from that in post-secondary settings. Much of the current efforts in the K-12 (secondary) sector have been to design learning objects for face-to-face classroom settings (Haughey & Muirhead, 2005). Designers have to take into account the culture and climate of classroom if they are to succeed in secondary schools.

In countries like Australia, Canada, the USA, the UK and Europe, there have been developments in the K-12 sector (Haughey & Muirhead, 2005). There are various databases of learning materials in these countries, though most of the materials do not qualify to be learning objects due to pedagogical usability issues. These might be considered more like

online repositories that contain artefacts, websites, and lesson notes (Haughey & Muirhead, 2005).

Standards bodies exist to in Australia, Canada, the USA, the UK and Europe to provide the overall guidance and standards for the development of the learning objects in schools.

In Canada, the initiative for the development of learning objects in secondary schools have been led by the work of learnalberta.ca portal. It is now being used as the basis for development of a national portal under the Committee of Ministers of Education, Canada (CMEC). Much of the development of the learning objects has been in the areas of English and French, mathematics and science for all grades.

In Australia and New Zealand, under the initiative of the Learning Federation, there has been development of learning objects in various areas, with initial feedback from teachers about their viability (Haughey & Muirhead, 2005).

In the UK, a web portal called CurriculumOnline was announced in 2003, which according to Haughey and Muirhead (2005) was designed "to give teachers easy access online access to a wide range of digital learning materials, which they can use to support their teaching across the curriculum" (Haughey & Muirhead, 2005).

In other parts of Europe, the European SchoolNet is a partnership of 26 European Ministries of Education interested in the educational use of ICTs for policy-makers and education professionals. It coordinates discussions and activities among teachers, students, policy-makers and commercial vendors. One of its projects is called CELEBRATE (2002-2004). This project was designed to examine how learning objects can enhance teaching and learning in European schools. Teachers accessed reusable learning objects, and also the tools and a virtual learning environment to make their own projects, build courses and communicate and collaborate with other developers. Over 1400 learning objects and 25 simple authoring templates were developed by commercial publishers and Ministry of Education. They were mainly in Mathematics, Science and Language with smaller numbers in other subjects ((Haughey & Muirhead, 2005).

The USA has got various databases of learning materials that comprise websites, lesson notes and learning objects. They range from sites like MERLOT (The Multimedia Educational Resource for Learning and Online Teaching) that are composed of various affiliations of Canadian and US tertiary institutions, SCORM (Shareable Courseware Object Reference Model) that strives to ensure access to high-quality education and training materials that can be tailored to meet individual learner needs and make available whenever they are required through the development of a common technical framework for computer and new-based learning that will foster the creation of reusable learning content as instructional objects, SMETE (Science, Mathematics, Engineering and Technology Educational content and services to the Apple Learning Services (Haughey & Muirhead, 2005). Some of these initiatives have standards bodies that basically develop technical standards, recommend practices, and guides for software components, tools, technologies and design methods that facilitate the development, deployment and interoperation of computer implementations of education and training components and systems. Examples include IEEE Learning Technology Standards Committee (LTSC), ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe) and IMS Global Learning Consortium which according to its website is "developing and promoting open specifications for facilitating online distributed learning activities such as locating and using educational content, tracking

learner progress, reporting performance, and exchanging student records between administrative system".

Some of the organisations above have formed a global alliance to make shared online learning resources available to educators and students around the world. The Global Learning Objects Brokered Exchange (GLOBE) was established between the following members: ARIADNE Foundation in Europe, Education.au in Australia, LORNET in Canada, Merlot in the USA, and National Institute of Multimedia Education (NIME) in Japan. These organisations have committed to work collaboratively on a shared vision of ubiquitous access to quality educational content. Globe community continues to grow with other organisations with similar goals attracted to join.

The development of learning objects in African schools is still in its infancy, though with various challenges. One current schools initiative is the Commonwealth of Learning(CoL)'s Learning Objects Repository (LOR), which provides open content course materials for teachers in all Commonwealth countries, using a free and open source software platform developed in Canada. The African Virtual University (AVU), based in Nairobi, is working with CoL to get learning objects relevant to African teachers into the repository.

There is also a NEPAD E-Schools project that aims to support internet connectivity for all the continent's high schools within 5 years, and primary schools in 10 years via wired and wireless systems. SchoolNet Africa, which has a presence in 30 African countries, is providing shared continental online networking spaces for teachers and learners through their African Education Knowledge Warehouse (AEKW) and African Teachers Network (ATN). It is also trying to build the necessary technical management and troubleshooting skills at school level. There is a challenge on whether these programmes have potential to gradually answer the digital part of the digital commons challenge due to lack of funding from the governments.

In Senegal, the Examen project, started in 2001 is a free web resource that helps high school students prepare for examinations and make career choices, with a focus on mathematics and science.

In South Africa, there is The Free High School Science Texts (FHSST) project, which is an online collaboration among materials developers around the world to build free science textbooks for grades 10-12.

Although there is remarkable progress being made in the adoption and diffusion of ICT in education throughout Africa; in terms of the broad impact, the process is just beginning (Farrell, Glen and Shafika I, 2007). Investment in ICT alone does not foster human development, but must be accompanied by investment in education and health (Morawczynski O. and Ng'enyama O. 2007).

1.2.5   Learning Objects in Computer Studies

In computer studies, various learning objects have been developed using multimedia authoring tools. The Merlot website has various information technology learning objects that can be accessed only after user registration and log in. A member can contribute any material, and the materials are peer-reviewed. The learning objects on the Merlot website are good for the students in higher education. We think that the learning objects for the

secondary school should be more user-friendly. Some of the learning objects are based on visualization tools, e.g. JELIOT system for animating introductory programs in Java. The learning objects on the internet are primarily intended for self-study. Some other schools have developed their own learning objects in computer studies. Generally, the learning objects currently in use today are meant for tertiary education, not for the secondary school level.

1.3   Methodology

The field of educational technology deals with the design and development of new or adapting existing technological interventions to solve current educational problems. Our problem is a development problem, which is concerned with the development of an intervention to solve a problem. This is design-based applied research. According to Randolph (2008), design-based applied research works well for developing educational activities or tools in educational technology. It blends empirical educational research with the theory-driven design of learning environments.

The design-based research has a fundamental characteristic of design, enactment, analysis and redesign. A preliminary study is carried out to determine how to improve an intervention. An intervention is perfected through cycles of design and testing. This begins with an informed exploration phase that includes problem identification, a literature review, problem definition, a needs analysis and audience characterization. The next phase, enactment, includes researching the initial intervention design, creating a prototype, and then developing a fully detailed intervention Randolph (2008), Wang & Hannafin (2004).

The approach by Hadjerrouit (2010) suggests user-centred development, where the goal of the developmental approach is to help developers to translate technical and pedagogical usability requirements into systems that support learning. The approach uses rapid prototyping in the design phase to produce a number of prototypes that can be revised through user feedback. A number of revisions are necessary to improve the quality of the learning objects through a continuous cycle of gradual refinement. This developmental approach consists of analysis, design, implementation and testing, and evaluation of the learning objects.

The basic steps suggested by Randolph (2008) and Hadjerrouit (2008) suggest a prototype to be designed first, and then the refinement of the prototype through user involvement. The approach in this work was to develop a number of prototype learning objects that can be improved through user feedback to improve their quality. The general software development process is to be followed, making sure that the learning objects are technologically and pedagogically usable before they can be fully used. This is work in progress that has managed to develop prototype learning objects. Future work involves testing our individual learning objects on a real school environment so that they can be improved with user feedback. Our users in this case are teachers and the students in secondary school. This means that the interfaces for the learning objects have to be user-friendly.

1.3.1 Learning Objects Design and Development

This work is about the design and development of the learning objects for the BGCSE computer studies control systems section in the secondary school level. It is not about how to present the learning objects to the users. The work involves designing individual learning objects. Future work will deal with designing the user interface if the overall all encompassing systems is to be developed. The functionality of concern is the individual learning objects that can be tested individually, and separately.

The development of the learning object in this work follows through the process of analysis, design, implementation, and testing. Analysis involves the objective that needs to be achieved by the learning object and basic skills required to learn. Design basically involves how to build the learning object and present it to the users, and which software tools to use, then a rapid prototype is built. Implementation involves the integration of various multimedia elements using programming languages and scripting languages. Testing intents to find out if there are any errors in the learning object and correcting them.

The criteria for pedagogical usability (Hadjerrouit 2010) like understandability, learner control, goal orientation, time, interactivity, motivation, multiple representation, differentiation, flexibility, autonomy, collaboration, variation will also be taken into account during the design and implementation to support the learning process. Technical and pedagogic usability are related to each other, and cannot be considered separate when designing learning objects. School students want modest, but clear design. They like enjoyable and visual appearance, online quizzes, and sound effects. They do not like to read a lot on the web (Hadjerrouit, 2010).

1.3.2 Software Tools

Various software tools have been used for the development of the learning objects. The major software application used was Adobe Flash Professional, and Actionscript scripting language. Flash Professional can be used to build animations, interactive learning objects, and graphics, and can combine various multimedia elements to build learning objects. We have also used java applets for some animations.

1.4 Proposed Learning Objects

We propose to design and develop a sample of learning objects that can be used in the BGCSE senior secondary school computer studies. These learning objects must incorporate instructional design theory. Although there have been other classifications, notably by Wiley (2000), the framework used by Churchill looks best for designers of digital resources.

Our learning objects were designed to be learner-centred, practical, collaborative, and engaging. Teachers and students should have an opportunity to interact and share with their fellow students in other parts of the world.
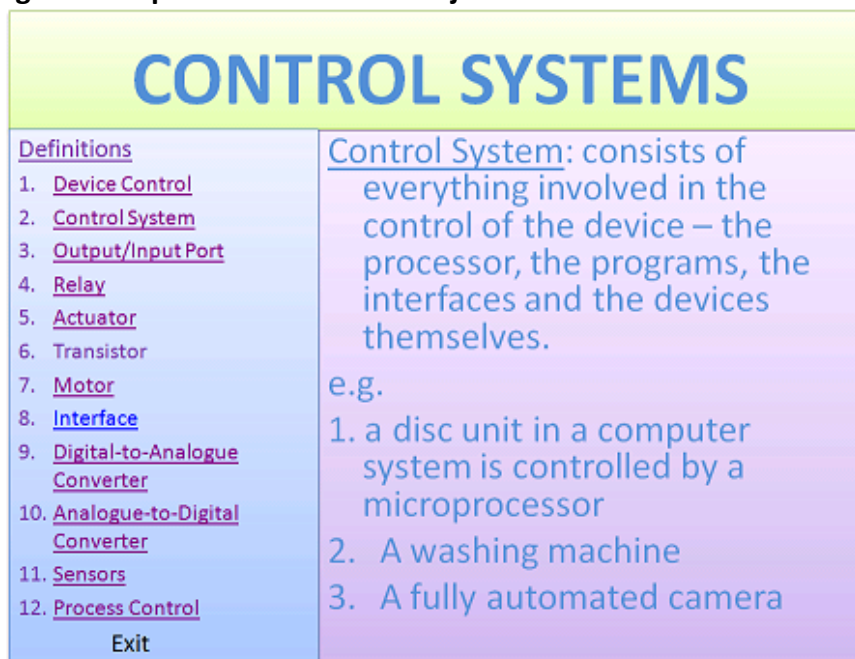
The learning objects that we design are categorized according to the classification by Churchill (2006). The classification of learning objects he proposed could be useful as a framework for designers of digital resources and for those engaged in use of these

resources in educational contexts. Churchill (2006) classified learning objects into six unique types which are presentation, practice, simulation, conceptual models, information and contextual representation objects.

1.4.1 Presentation Objects

Include resources designed with a purpose to transmit a body of subject matter or lead to achievement of a specific learning objective. A presentation object attempts to transmit knowledge to learners by displaying messages representing chunks of subject matter (Churchill, 2006). This could involve pages of hyperlinked documents with information leading to achieve a certain objective from the syllabus. Presentation material and/or word processed could be usefully used for these kinds of objects.

Fig. 1: Example of Presentation Object

1.4.2 Practice Objects

Practice objects allows learners, to practice certain procedures (e.g., dry run an algorithm), complete crosswords, drag objects, engage with an educational game or answer quiz questions. These incorporate interactivity between the interface and the students during learning of a concept.

1.4.3 Simulation Objects

Simulation objects represent some real system or process. They allow the learner to explore operational aspects of a system, thereby developing a mind model of the system's functionalities. In secondary school computer studies, topics in control systems to simulate a real system in place can be easily simulated for effective learning to take place.

Fig. 2: Diagrammatic Representation of ADC

1.4.4 Conceptual model objects

A conceptual model is a type of a learning object that represents one or more related concepts or ideas, usually in an interactive and visual way. It might be appropriate to think of a conceptual model as a representation of a cognitive resource existing in the mind of a subject matter expert, as useful conceptual knowledge that aids decision-making, disciplinary problem-solving and discipline-specific thinking (Churchill 2006).
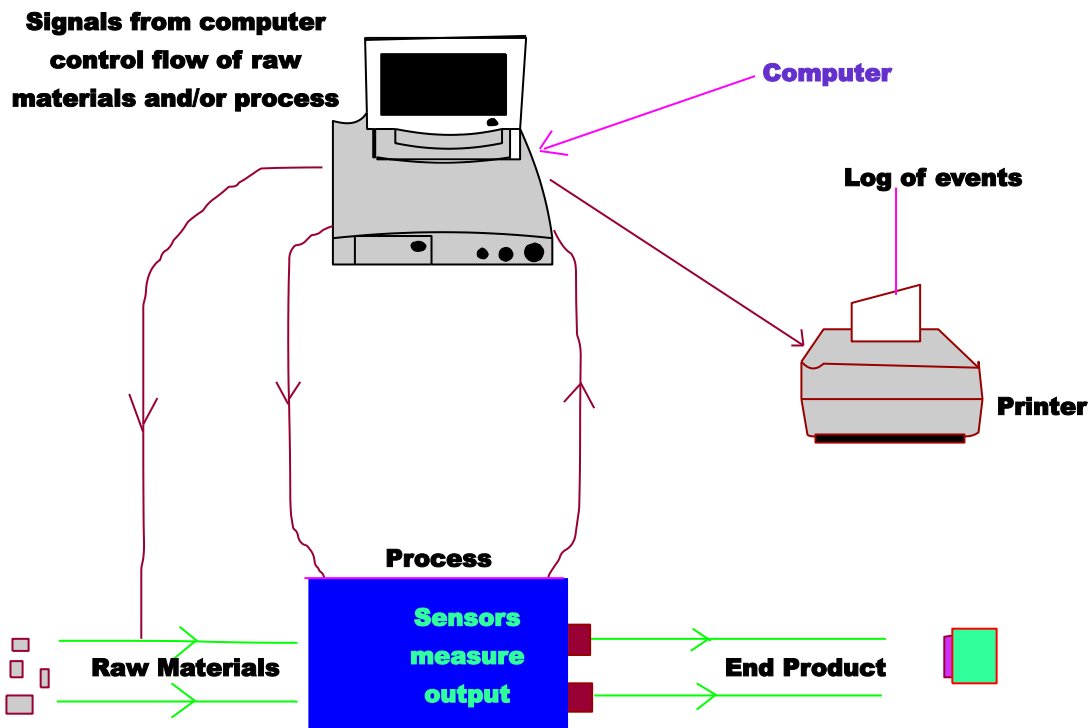
Fig. 3: Diagram of a Control System
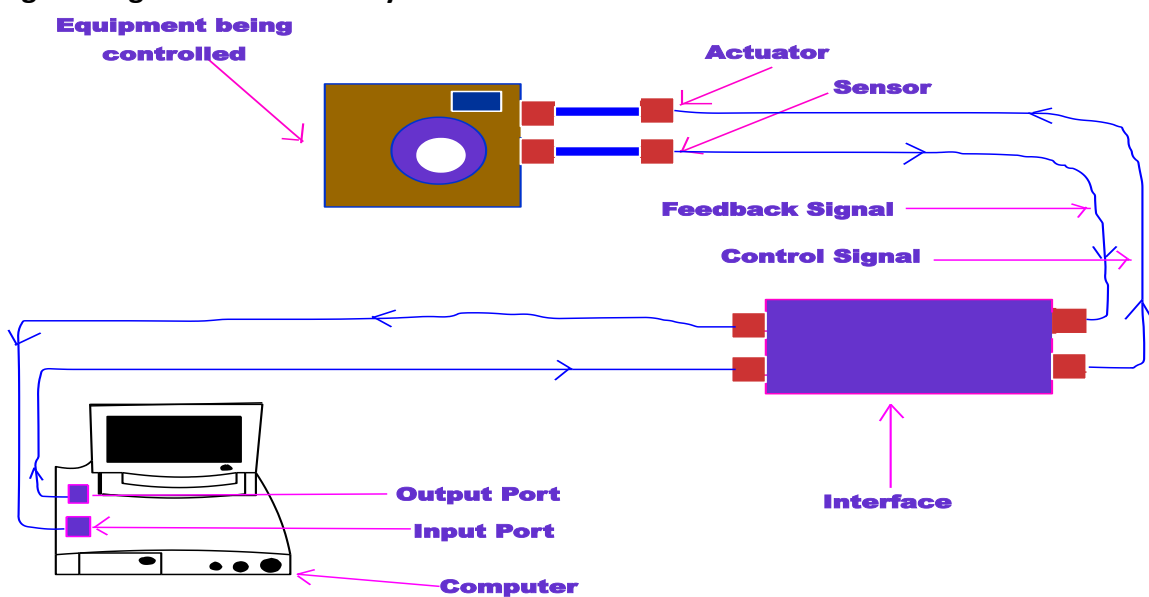
1.4.5 Information objects

An information object utilizes information visualization capabilities of contemporary technology to provide educationally useful information. This type of learning object might be just a single representation (an image) or a multimodal display and a visual interface providing information dynamically based on interaction. An animation to reinforce a skill or even to introduce a concept is an example of information object.

Fig. 4: Information Object - Process Control System

Signals from computer control flow of raw materials and/or process

Computer

Log of events

Printer

Process

Sensors measure output

Raw Materials

End Product

1.5   Conclusions and Future Work

A variety of learning objects should be used in secondary schools in African countries to take advantage of current advances in technology. Learning objects can be designed and deposited in a user friendly environment where the teachers could access them online. They are stored in digital repositories to be used by teachers and students. These digital learning resources can be used by school children in class under the guidance of the teacher, or at home after school for their own benefit.

This work allows us to examine learning in naturalistic contexts, many of which are designed and systematically changed by the researcher. Our thinking is that this necessitates the development of a methodological toolkit for deriving evidence-based claims from these contexts. Context-based computer studies education projects similar to this have rarely been carried out in developing countries, thus there is need to carry out this type of multidisciplinary approach. Also, local innovation and creativity are critical to the welfare of the local communities than is the mere availability of technology from other places.

This paper only deals with the design and development of the learning objects and does not include the empirical part of the research because the research is still in progress. We propose a follow-up paper to address empirical issues. A user-centred approach to the development of the learning objects will be followed. Rapid prototyping has been used in the design phase to produce a number of learning objects that can be used to get user feedback. This first development of a prototype will be used in the design phase, and then from here onwards participation of the users will be given a high priority. User feedback will be used to improve the learning objects.

Context-based ICT education projects like this have rarely been carried out in developing countries, thus there is need to carry out this type of multidisciplinary approach. Also, local innovation and creativity are critical to the welfare of the local communities than is the

mere availability of technology from other places. It is our hope that the development of these digital resources will help students and teachers to better manage their computer studies learning activities. These learning objects could be developed once and be used across the curriculum in various places at once.

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