ISSN 1934-7332 (Print)
ISSN 1934-7340 (Online)

Computer Technology and Application

Volume 4, Number 9, September 2013

David Publishing Company
www.davidpublishing.com

From Knowledge to Wisdom

Computer Technology and Application

Volume 4, Number 9, September 2013 (Serial Number 34)

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Publication Information:
Computer Technology and Application is published monthly in hard copy (ISSN1934-7332) and online (ISSN1934-7340) by David Publishing Company located at 16710 East Johnson Drive, City of Industry, CA 91745, USA.

Aims and Scope:
Computer Technology and Application, a monthly professional academic journal, particularly emphasizes practical application of up-to-date technology in realm of computer and other relevant fields. And articles interpreting successful policies, programs or cases are also welcomed.

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Editorial Office:
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Abstracted / Indexed in:
Cabell's Directory, USA
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Database of EBSCO, Massachusetts, USA
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Index Copernicus, Poland
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Subscription Information:
Price (per year): Print $520; Online $360; Print and Online $680

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Hybrid Task and Message Scheduling in Hard Real Time Distributed Systems over FlexRay Bus

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Received: September 8, 2013 / Accepted: September 15, 2013 / Published: September 25, 2013.

Abstract: FlexRay is a vehicular communication protocol designed to meet growing requirements in hard real time automotive systems and to support time triggered as well as event triggered paradigms. Thus, there has been a lot of recent interest in timing analysis techniques in order to provide bounds for the message communication times on FlexRay. In this paper, we present an approach to compute the WCRT (worst case response time) for periodic and sporadic tasks, within a FlexRay node, responsible for sending messages on the FlexRay SS (static segment) and DS (dynamic segment). On the other hand, we propose a scheduling table for messages transmitted over the FlexRay SS. An interesting innovation would be the use of a scheduling algorithm performed on a FlexRay node to guarantee the arrival of the right data on the right time and to ensure that every task meets its deadline. As application, we will use the extended SAE (society of automotive engineers) benchmark for the FlexRay network to identify the static and dynamic tasks, and calculate the response time, based on a hybrid scheduling model to further prove that the deadline of the SAE benchmark applications is insured.

Key words: FlexRay, fixed scheduling, periodic tasks, WCRT, SAE benchmark.

1. Introduction

Timing requirements are the basic aspects of RTSs (real-time systems) since they are requisite to react to stimuli from the environment within time intervals dictated by this latter. According to timing requirements, we distinguish hard and soft RTSs. The response time of a hard RTS must occur within specified deadlines, while a soft RTS functions correctly if the deadline is occasionally missed.

From an analytic point of view, a RTS is usually represented by a set of tasks including each one a number of jobs that are executed in a cyclic way. Execution of tasks is controlled by the operating system using some scheduling algorithms. This former controls and coordinates the use of the hardware among various application programs within the user tasks [1]. In other words, application software is usually designed as a number of separate tasks that are scheduled by the operating system via the scheduler; which is the part of the kernel that determines the next runnable task [2].

Real-time tasks are divided, according to their arrival times, into periodic and sporadic tasks. The arrival times of periodic tasks are fixed so that each task arrives into the system every fixed interval of time, called a period. On the other hand, the arrival times of a sporadic task are not fixed; instead, the task has a minimum interval of time to arrive in the system. A basic ordinary periodic real-time task is usually

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characterized by three parameters. The first parameter characterizes the time that a task takes during the execution of its jobs (the execution time C). The second characterizes its arrival times (the period P). The third and last one is the deadline D that characterizes the time in which a task has to complete the execution of its jobs.

As scheduling is a fundamental function of operating systems responsible for determining the order in which tasks are executed, many researches are concerned with this area to either construct schedulable systems or to analyze the schedulability of proposed systems. Schedulability of real time systems reflects the feature indicating whether a system, represented by a set of real-time tasks, can meet their deadlines. A scheduling scheme provides two features; an algorithm for ordering the use of system resources and a means of predicting the worst-case behavior of the system when the scheduling algorithm is applied. A scheduling algorithm is feasible if the tasks are scheduled so that no overflow ever occurs. And an optimal scheduling algorithm is the one that may fail to meet a deadline only if no other scheduling algorithm can meet it.

We distinguish two types of scheduling algorithms known as dynamic scheduling and static scheduling algorithms. A dynamic scheduling algorithm has a complete knowledge of currently active tasks, but new task activations, not known to the algorithm when scheduling the current set, may arrive. So, the schedule changes over time. However, in static scheduling, the scheduling algorithm has a complete knowledge of the task set and its constraints, such as deadlines, computation times, precedence constraints, and future release times. This set of assumptions is realistic for many real-time systems and the static scheduling algorithm operates on a known set of tasks and produces a single schedule that is fixed for all time.

The remainder of this paper is organized in 6 sections. In section two we overview communication protocols and we present differences between TT (time triggered) and ET (event triggered) paradigms. We present in section three a historical study on vehicle networking and we focus on the FlexRay bus. Section four is devoted to introducing real time scheduling issues and we finish by section five in which we present a real case study that consists of applying the studied technique on a vehicle prototype in order to check task and message schedulability and timing bound within different bus speeds of the FlexRay bus.

2. TT versus ET Communication Protocols

2.1 ET Protocols

In an ET system, traffic gets input onto the network after an event has occurred. This is called asynchronous transfer because there is no predetermined time at which these events will occur. Because any event can occur at any time in any order, the network has to have a developed system that will avoid collisions if two messages on two separate nodes try to gain access to the network at the same time. This is achieved by tagging each message with a priority level. The message with the highest priority will be granted access to the bus once it is free. This is an efficient use of bandwidth due to the fact that only messages that need to be transmitted will be looking for access to the network. An event triggered communication controller does not need a dispatching table because the transmission of a message is triggered by a send command from the host [3-4].

2.2 TT Protocols

With a TT protocol, transmission occurs at predefined points in time [5-7]. Activities can only occur with the progression of time and the activity is predefined. This requires the network to have a pre-defined schedule that assigns activities a section of the time (time slot) to perform the required action. Each task is made up of messages. If a message is not transmitted in its defined time slot it waits until its next time slot. A TT communication controller contains a dispatching table in its local memory that determines what point in time a particular message is transmitted or when that message is expected to be received [4].

3. In Vehicle Networks and FlexRay

3.1 In Vehicle Networks History

Due to the increased levels of new features and applications in automobiles, it was mandatory to introduce networks and communication protocols into modern vehicles. Several solutions were proposed and it was up to design engineers to decide what protocol is to be runned on the network with regard to his application requirements in term of cost, speed and technology availability. Therefore, in the past few years, several communication protocols have been developed.

The CAN protocol have been developed by Bosch and nowadays used by almost every car manufacturer. It supports data rates of up to 1 Mbit/s. The LIN (local interconnect network) protocol has been developed for less demanding applications in terms of communication speed and latency. In contrary, the MOST (media oriented systems transport) bus satisfies the high data rates needed for multimedia applications. Finally, FlexRay has been especially developed for safety related applications in the automotive industry and to support x-by-wire applications such as steer-by-wire or brake-by-wire as replacement of the traditional mechanical and hydraulic control systems through electronic control systems.

3.2 FlexRay Network Features

FlexRay features two communication channels, each with a data rate of 10 Mbit/s, and payloads of frames up to 254 Bytes. Furthermore, the communication is both event and time triggered in contrast to the event triggered CAN protocol. This is why FlexRay guarantees fixed communication latencies and a global synchronous time basis for all participating electronic control units. Furthermore, the FlexRay network is very flexible with regard to topology and transmission support redundancy. It can be configured as a bus, a star, or a multi-star. It is not mandatory that each node possess neither replicated channels nor a bus guardian, even though this should be the case for critical functions such as steer-by-wire. At the MAC (medium access control) level, FlexRay defines a communication cycle as the concatenation of a TT (or static) window and an ET (or dynamic) window. In each communication window, which the size is set statically at design time, two distinct protocols are applied. The communication cycles are executed periodically. The TT window uses a TDMA (time division multiple access) MAC protocol which consists of a fixed number of static slots incrementally counted by a slot counter in each FlexRay cycle starting from 1 to cSlotIDMax. The bus arbitration is performed by uniquely assigning frame identifiers to nodes such that in each static slot, the node with the frame identifiers that is equal to the current value of the slot counter can send a message [5-8]. The main difference with TTP/C [7] is that a node in FlexRay might possess several slots in the TT window, but the size of all the slots is identical. In the ET part of the communication cycle, the protocol is FTDMA (flexible TDMA): the time is divided into so-called minislots; each node possesses a given number of minislots and can start the transmission of a frame inside each of its own minislots. A minislot remains idle if the node has nothing to transmit [6].

4. Scheduling Policies

4.1 TT/Static Scheduling

Among several static scheduling techniques, we mention round-robin scheduling and SCS (static cyclic scheduling). The latter technique, known also as clock-driven scheduling, is adapted in this work and consists on building offline a scheduling table stored in the memory before the system start to operate. At run-time, a dispatcher follows the schedule and makes sure that tasks are only executing at their predetermined time slots. After the scheduler dispatches a task, it sets the periodic timer to generate an interrupt at the next task switching time. The scheduler will then go to sleep until the timer expires. This process is repeated throughout the whole operation. For each task, the time instant to execute is fixed, so the response time for each task is very predictable. Therefore, it suits the safety-critical applications [9].

4.2 ET/Dynamic Scheduling

Event triggered scheduling includes DPS (dynamic priority scheduling) and SPS or FPS (static (fixed) priority scheduling). DPS algorithms (e.g., LCT (least completion time), EDF (earliest deadline first) and LST (least slack time)) assign priorities based on current state of the system. While FPS algorithms assign fixed priorities to processes and the scheduler only needs to know about priorities in order to allocate the CPU (central processing unit) to the highest priority runnable task. In FPS scheme all invocations of each task are assigned the same priority, so the priority of each task is fixed relative to other tasks in the system [10]. Fixed priority scheduling is recommended for many years as it is capable to predict the ability to meet application response requirements. RM (rate monotonic) algorithm is the optimal static-priority scheduling assigning priority according to period. A task with a shorter period has a higher priority and the processor executes a job with the shortest period first.

4.2.1 Schedulability and Timing Analysis

In this part, we will focus on the RM algorithm to study its feasibility first, and then to compute the WCRT of a given task. In fact, a RTS is schedulable under RM if and only if, for all tasks [11]:

$$R_i \le T_i \tag{1}$$

Or if the use bound defined in Eq. (2) satisfies.

$$U \equiv \sum_{i=1}^{N} \frac{C_i}{T_i} \le N(2^{1/N} - 1) \tag{2}$$

where N denotes the number of tasks, C_i is the WCET (worst-case execution (computation) time) of the task "i" and T_i its period. This condition is sufficient but not necessary [12].

4.2.2 Response Time Computing

The response time is the duration from released time to finish time of a task. It is given by the equation below [13]:

$$R_i = C_i + I_i \tag{3}$$

where "i" is caused by the interference from higher priority tasks and consists in a sum of the number of each higher priority task releases during R_i. In other word, it is the number of times where each higher priority task can execute during R_i. The interference caused by a task "j" is given by:

$$\left\lceil \frac{R_i}{T_j} \right\rceil C_j \tag{4}$$

where the ceiling function gives the smallest integer greater than the fractional number on which it acts.

$$R_i = C_i + \sum_{j \in hp(i)} \left\lceil \frac{R_i}{T_j} \right\rceil C_j \tag{5}$$

where $hp(i)$ is the set of tasks with priority higher than task "i". Since R_i appears in both two parts of the equation, we have to solve by forming a recurrence relationship:

$$w_i^{n+1} = C_i + \sum_{j \in hp(i)} \left\lceil \frac{w_i^n}{T_j} \right\rceil C_j \tag{6}$$

The set of values $w_i^0, w_i^1, w_i^2, \ldots, w_i^n$ is monotonically none decreasing. When $w_i^n = w_i^{n+1}$, the solution to the equation has been found.

5. The Application Model

To illustrate the utility of our comprehensive scheduling strategy, we have chosen to work within a platform of a vehicular network based on the SAE standard. In this system, a set of network processors subsystems produces routing data. This data must be distributed along the vehicular network. In fact, we will apply the studied approaches on a new vehicle benchmark developed in Ref. [14] and based on the SAE benchmark (Fig. 1). The author has added to the original benchmark a number of nodes and messages to better represent the complexity of today's vehicles and to model some added options responsible for improving vehicle safety, reliability, cost, and luxury. However, this

Benchmark was designed to best fit the CAN network and it needs major modifications to be adapted to the FlexRay protocol. Hence, later in this section, we will explain how to introduce adjustments to that model and we will apply our scheduling algorithm and present our results for the new model. The resulting architecture is composed of 15 nodes connected by the FlexRay bus.

According to the FlexRay specification and as shown in Fig. 2, each node consists of a host (CPU) that processes incoming messages and generates outgoing messages, a CC (communication controller) that independently implements the FlexRay protocol services, and a two-way CHI (controller-host interface) that serves as a buffer between the host and the CC. The main goal of the proposed architecture is to insure better performance of the vehicular network and to guarantee the arrival of the right data on the right time by meeting the tasks deadline. The framework architecture is a set of nodes connected via FlexRay real-time transport protocol. In each node, a real-time operating system μCOSII and a publish/subscribe middlewar is embedded.

5.1 Process Scheduling

Process scheduling takes place on the CPU of each node where there is a real-time kernel that performs aperiodic and sporadic tasks thanks to the presence of two hybrid scheduling method processing simultaneously schedulers; a SCS dedicated to implement periodic tasks and a FPS processing sporadic tasks (Fig. 3).

When several tasks are ready on a node, the task with the highest priority is activated, and preempts the other tasks.

Periodic tasks that have to be non preemptable are assigned the highest priority level "0" so that they are never interrupted by other tasks within the schedule. Hence, sporadic tasks can only be executed in the slack of the SCS schedule table.

SCS activities are triggered based on a local clock in each processing node. The synchronization of local clocks throughout the system is provided by the communication protocol [8].

Computing time C_i of a given message was calculated in a previous work [15] based on the size of executed message and taking in account the communication time. In other words, the computing time of a message includes its execution delay on the corresponding node and the transmission time over the FlexRay bus.

In our case, the utilization bound U is equal to 0.0235 which is lower than the factor $N(2^{1/N}-1)$ that equals here 0.104. In consequence, the sufficient relation (2) is satisfied and our system is schedulable. Then, we can implement our algorithm to compute WCRT for different messages.

As application examples, we consider the BCM

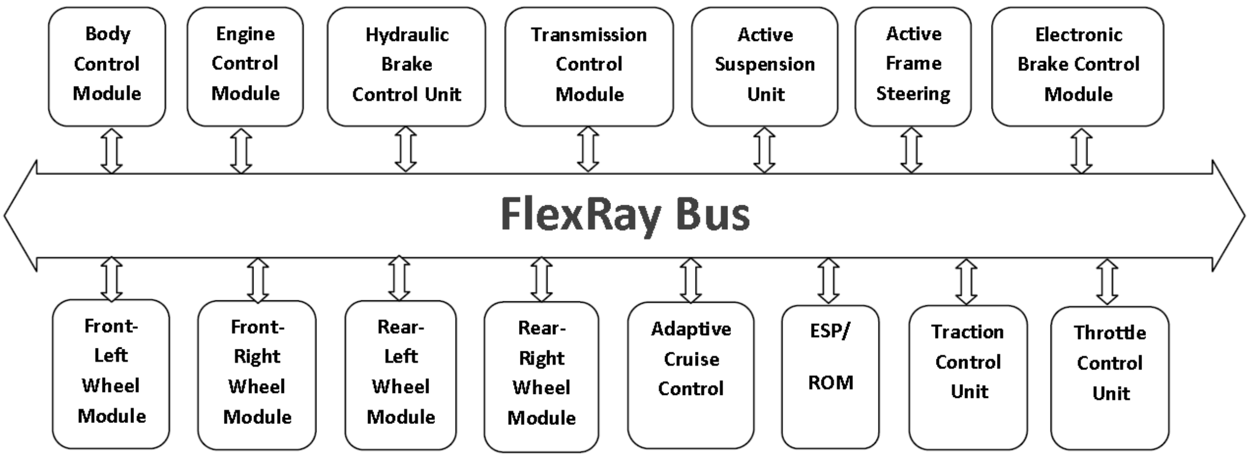

Fig. 1 The application model.

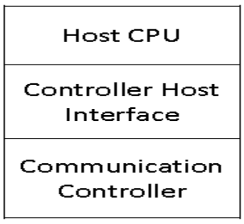

Fig. 2 The FlexRay node structure.

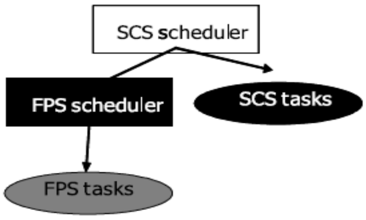

Fig. 3 Scheduling system architecture on a FlexRay node [9].

(body control module) node and the ECM (engine control module) node of the extended SAE benchmark.

The ECM combines the vehicle controller and inverter/motor controller modules of the original SAE benchmark. While the BCM node combines the driver and battery modules of the original SAE benchmark. This module acts usually as a gateway between the low-data rate and the high-data rate networks in a vehicle.

The BCM node processes 7 tasks and the ECM node processes 6 tasks as shown in Table 1 and Table 2. These tables show also the designation and description of each sending task, priority of each message (P) and its period (T) in ms.

Based on the dynamic scheduling method seen before, we propose the following hybrid scheduling algorithm in the sense that it implements periodic and sporadic tasks simultaneously (Fig. 4).

Applying this algorithm with 3 different bus speeds; 5 Mbit/s and 10 Mbit/s for one channel transmission scheme, and 20 Mbit/s for both channels transmission scheme, we obtain the results presented in Table 3.

Table 3 and Table 4 show that for this three bus speeds, all tasks on the considered nodes are schedulable and that they never exceed message Deadlines.

To better represent these results we give in Figs. 5-6,

Algorithm: Worst Case Response Time Computing

for i in 1..N loop
  calculate C_i
  n:= 0
  loop
    calculate new w_i^{n+1}
    if $w_i^{n+1} = w_i^n$ then $R_i = w_i^n$
      exit value found
    end if
    if $w_i^{n+1} > T_i$ then
      exit value not found
    end if
    n:= n + 1
    end loop

Fig. 4 Hybrid scheduling algorithm implementing periodic and sporadic tasks simultaneously.

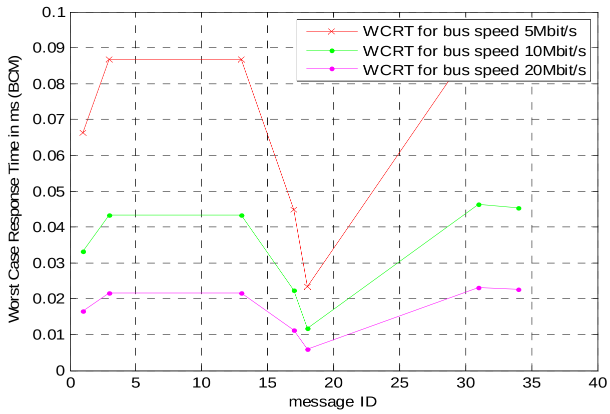

Fig. 5 WCRT for the BCM node.

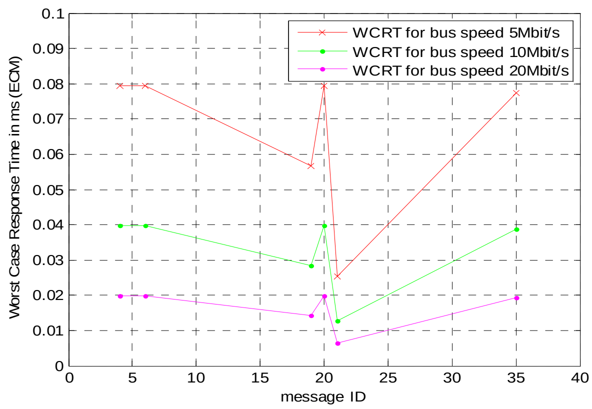

Fig. 6 WCRT for the ECM node.

two graphs showing the evolution of the WCRT of messages within the BCM node and the ECM node of our extended SAE benchmark with three different FlexRay bus rates.

On Figs. 5-6, we can also notice that the WCRT of a given message decreases when the bus speed increases.

Table 1 Task set on the BCM node.

ID	Task designation	Description	P	Size (Bytes)	T (ms)
1	HLC_W_T()	Hi&Lo contactor open/close	1	1	50
3	AP_W_T()	Accelerator position	0	1	5
13	BPP_W_T()	Brake pedal position	0	1	5
17	ACK_W_T()	Acknowledgments	2	1	10
18	CSW_W_T()	Control switches	3	2	10
31	BVC_W_T()	Batteries voltage and current	0	4	100
34	TBM_W_T()	Traction battery measurement	0	3	1,000

Table 2 Task set on the ECM node.

ID	Task Designation	Description	P	Size (Bytes)	T (ms)
4	MST_W_TASK()	Motor speed and torque	0	2	5
6	PMC_W_TASK()	Pressure and main contactor	0	2	5
19	VCS_W_TASK()	Vehicle controller sporadic signals	1	6	10
20	CCS_W_TASK()	Contactor control signals	0	2	10
21	MCS_W_TASK()	Motor controller sporadic signals	2	3	10
35	CBT_W_TASK()	Converter and battery test	0	1	1,000

Table 3 WCRT computing results for the BCM node.

Task designation	WCRT R (ms)		
	Bus speed 5Mbit/s	Bus speed 10Mbit/s	Bus speed 20Mbit/s
HLC_W_T()	0.0662	0.0331	0.0166
AP_W_T()	0.0868	0.0434	0.0217
BPP_W_T()	0.0868	0.0434	0.0217
ACK_W_T()	0.0448	0.0224	0.0112
CSW_W_T()	0.0234	0.0117	0.0059
BVC_W_T()	0.0928	0.0464	0.0232
TBM_W_T()	0.0908	0.0454	0.0227

Table 4 WCRT computing results for the ECM node.

Task designation	WCRT R (ms)		
	Bus speed 5Mbit/s	Bus speed 10Mbit/s	Bus speed 20Mbit/s
MST_W_TASK()	0.0794	0.0397	0.0199
PMC_W_TASK()	0.0794	0.0397	0.0199
VCS_W_TASK()	0.0568	0.0284	0.0142
CCS_W_TASK()	0.0794	0.0397	0.0199
MCS_W_TASK()	0.0254	0.0127	0.0064
CBT_W_TASK()	0.0774	0.0387	0.0193

5.2 Communication Scheduling

5.2.1 Software Architecture

For the simulation, we consider a set of FlexRay nodes sending 36 messages on the FlexRay bus. Since each node in the system that generates static messages needs at least one static slot, the minimum number of static slots is the number of nodes (nodes ST) that send static messages [8]. In the extended benchmark [14], there are 15 nodes sending 36 messages among which there are 30 periodic messages that need to be scheduled on the FlexRay static segment. The remaining six messages are sporadic and need to be mapped into the dynamic segment.

The period of the bus cycle (gdCycle) must be lower than the maximum cycle length cdCycleMax equal to 16 ms and has, also, to be an integer divisor of the period of the global static segment. In addition, each node has a counter vCycleCounter in the interval 0…63. Thus, during a period of the global static schedule there can be at most 64 bus cycles.

Observing our message set, we have noticed that almost all of the message periods are multipliers of 5 ms; so we can fix the period of the bus cycle to 5 ms andadjust some message periods, especially the messages introduced by Ben Gaid, M-M in Ref. [16] and others introduced by M. Utayba in Ref. [14]. All messages with period equal to 8 ms will have a period of 5 ms, and messages with period equal to 12 ms will have 10 ms as new period. This will not affect our system efficiency since it will make it faster and more reactive.

There is another problem concerning messages with a period of 1,000 ms that makes them not schedulable.

In fact, even if we consider the longest period of the global static schedule (64 bus cycles), we would not manage to reach the 1000 ms. Thus, we have to decrease this period to 64 × 5 = 320 ms.

We have also replaced the original bus priorities designed for an event triggered bus (CAN) by a local priority table to order transmission of messages having the same Frame Identifier on different slots assigned to their source node.

Table 5 shows different nodes sending static messages with their corresponding frame identifiers, the local priority and the period of each static message in ms.

Based on the previous study and taking into account that a static schedule consists of elaborating a schedule table of our message set, we propose Table 6 for scheduling our 30 periodic messages on the FlexRay SS.

6. Conclusions

In this paper, we presented a method for fixed priority task scheduling on a FlexRay node and a static cyclic approach to message scheduling on the SS of the FlexRay bus. To evaluate those two approaches performances, we have applied our study to the extended SAE benchmark after introducing some changes in order to adapt it to the FlexRay protocoll requirements. In future works, we intend to enhance our study by the FlexRay configuration and timing

Table 5 Periodic message set.

FlexRay Node	Frame Identifier	Local Priority	T [ms]
BCM	1	1	5
		2	5
		3	100
		4	320
ECM	2	1	5
		2	5
		3	10
		4	320
HBCU (Hydraulic Brake Control Unit)	3	1	5
		2	100
TCU (Transmission Control Unit)	4	1	5
		2	100
		3	320
Front-Left Wheel Module	5	1	5
		2	10
Front-Right Wheel Module	6	1	5
		2	10
Rear-Left Wheel Module	7	1	5
		2	10
Rear-Right Wheel Module	8	1	5
		2	10
Active Suspension Unit	9	1	10
AFS (Active Frame Steering)	10	1	10
Electronic BCM	11	1	5
Throttle Control Unit	12	1	5
Traction Control Unit	13	1	5
		2	5
ESP/ROM	14	1	5
		2	10
ACC (Adaptive Cruise Control)	15	1	10

Table 6 The global SS table.

FlexRay node	Frame identifier	Slot number	Cycle number
BCM	1	1	All cycles
		2	All cycles
		3	Every 20 cycles
		4	First cycle only
ECM	2	5	All cycles
		6	All cycles
		7	Every two cycles
		8	First cycle only
HBCU	3	9	All cycles
		10	Every 20 cycles
TCM	4	11	All cycles
		12	Every 20 cycles
		13	First cycle only
Front-left wheel module	5	14	All cycles
		15	Every two cycles
Front-right wheel module	6	16	All cycles
		17	Every two cycles
Rear-left wheel module	7	18	All cycles
		19	Every two cycles
Rear-right wheel module	8	20	All cycles
		21	Every two cycles
Active suspension unit	9	22	Every two cycles
AFS	10	23	Every two cycles
Electronic BCM	11	24	All cycles
Throttle control unit	12	25	All cycles
Traction control unit	13	26	All cycles
		27	All cycles
ESP/ROM	14	28	All cycles
		29	Every two cycles
ACC	15	30	Every two cycles

parameters definition (static and dynamic segment lengths, static slots size, and the number of macro-ticks within every static slot). We intend also to study the case of the FlexRay DS scheduling and its FTDMA protocol implementation. Also, we will calculate the response time, based on the full scheduling model, taking into account all the sources of delay, and introduce it into our system to further prove that the QoS of SAE benchmark are insured [17].

Acknowledgments

The researchers presented in this paper would not have been possible without the support of my professors and colleagues. We wish to express our gratitude to the Sys'Com laboratory ENIT members as well as the LSE Laboratory ENIT members for their help and assistance.

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Computer Technology and Application 4 (2013) 454-458

Simulations of Using Vectors in Natural Sciences Education

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Received: August 26, 2013 / Accepted: September 9, 2013 / Published: September 25, 2013.

Abstract: The implementation of ICT (information and communication technologies) into the educational process is becoming a reality in the 21st century. Today's students grow up with technology. To keep their attention, scientific problems should be solved through visualization, which is made possible using ICT in the educational process. In the modern educational process, students still have difficulties in learning science concepts. Also, it is a very common problem that students cannot apply mathematical language and concepts into other science areas such as physics, engineering, etc. For example, students start learning about vectors in mathematics in secondary school. Vectors are very important because they have a wide area of applications especially in physics, engineering and navigation to represent forces, tension, velocity, etc.. Using the free mathematical software GeoGebra, a simulation of using vectors in these areas is made. It will be shown that such simulations increase students' interest, keep their attention, and make this knowledge more real and more understandable and connected to the physical world and thus more applicable to their other studies.

Key words: Education, GeoGebra, ICT, vectors.

1. Introduction

An indisputable fact is that mathematics is a fundamental science; it is the foundation for all other natural sciences. No other natural science can be imagined without the existence of mathematics. On the other hand, because mathematics is still a problem for a large number of students, there is a need to find ways through which this fundamental science will be more accessible, so that students with greater understanding and enthusiasm will master its principles. Modern educational methods and the use of information and communication technologies in visualizing and manipulating mathematics are important.

Certain quantities in physics are represented using mathematical concepts. For example, force, displacement and velocity are represented by the mathematical concept of vector. Vectors are one of mathematical concepts that have application in all other natural sciences. This makes them a good choice to explain the solution of mathematical and other sciences problems with the help of the dynamic mathematic software.

The main purpose of this paper is to use free and open source software to develop instructional materials about vectors for use in all scientific fields. The teaching materials, which can be made by the teachers or by the students, are actually simulations of real-life problems that are resolved by means of vectors. They provide better visualization of the real-life problems and at the same time a better understanding of mathematical principles.

For this purpose, the mathematical software GeoGebra is used. GeoGebra is the software application which consolidates algebraic and geometric solutions which provides excellent

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visualization of a given problem based on the algebraic calculations. Also, GeoGebra provides an opportunity to experiment with different initial values in a given problem, and to draw conclusions based on the obtained solutions.

2. Previous Research about Student Understanding of Vectors

According to Ref. [1], vectors are an essential component of the mathematical language of physics, even at the introductory level. But the primary conclusion drawn from his test is that only about one-third of the students in a calculus-based introductory course have sufficient vector knowledge to proceed with mechanics, while a full 50 percent of the class enters with no useful knowledge of vectors at all.

In Ref. [2], authors found that ideas about vectors addition and subtraction are often more difficult for students in a physical context.

According to their research, the authors in Ref. [3] conclude that significant additional instruction of vectors may be needed if introductory physics students are to master those concepts.

In Ref. [4], Flores said that most undergraduate students have a problem understanding fundamental physics concepts, primarily with vector operations. The developments of the mathematical objects that represent physical concepts determine a cognitive evolution of the students' mathematical structures in the learning physical concepts.

From the cited authors, it is obvious that the concept of vector is not understandable for a large number of students. To explain vectors, the new approach should be offered. Using software to explain the concept of vectors is a contemporary approach that simultaneously includes one of the basic mathematical pre-requisite skills: visualization.

On the other hand online research about the computer simulations of vectors application shows that there are not a lot of interactive teaching materials in this area. For example, one of the most widely used programs Phet does have an interactive and it is good, you can download or embed freely, but it is severely limited in its possibilities and it does not show the math, which is the key.

Phet is available at: http://phet.colorado.edu/en/simulation/vector-addition

3. Using ICT in Science Education—Methodology

According to Ref. [5], one of mathematics pre-requisite skills is visualization. This skill has a significant rule in mastering vectors, especially using vectors in different situations and in different sciences fields. For example, if the student has to solve an exercise with forces that acted on a body, he/she must visualize where the force actually acts and the direction of it. One approach is to draw such situations on a piece of paper, but what if the initial conditions are changed? The students have to draw a number of situations in order to make a conclusion, especially if the problem is complex.

Here is where the implementation of information and communications technologies into the educational process is vital. There are a number of ways that ICT can be implemented in the educational process in general, with special accent to science education. For this purpose, GeoGebra—the free dynamic mathematic software for learning and teaching is used to make simulations of real-life problems which include vectors in their solutions.

The two problems taken as a basis for our research require that the students have a mathematical background in solving right triangle geometry and its algebraic descendant trigonometry. The students also must be familiar with the vectors and addition of vectors.

Often these concepts are taught separately and connecting them mathematically and to the physical science in question is quite difficult for the student.

The idea is that teachers solve this or a similar problem by creating a simulation (GeoGebra applet) in real-time in the classroom and then students make their own applet. In this way, students can first check that the applet works with the solved problem and then go on to use the applet to solve (or check their hand solution to) other such problems. In addition to learning the actual material at hand, it also teaches students proper problem solving techniques [6].

4. Development of ICT Model

As said above, in order to explain the advantages in using computers and ICT in educational process, two examples are examined in detail. The first example concerns the application of vectors in navigation and the second example concerns the suspension of a weight from two wires.

Example 1 [7]: A jet airliner, flying due east at 800 km/hr in still air, meets a 250 km/hr tailwind blowing in the direction 60 degrees north of east. The airplane holds its compass heading due east, but because of the wind, acquires a new ground speed and direction. What are they?

The mathematical solution is used as a basis for creating the computer model (simulation). In Fig. 1, a solution to this problem using GeoGebra is given. The simple problems can be solved in a few steps. The construction protocol for exercise 1 is shown in Fig. 2 (the solution include 20 steps excluding text). In particular, notice step 9 where the second vector is defined using trigonometry. It is important that the student see that the trigonometry gives the geometry (parallelogram).

The other advantage of using software to solve this exercise is that the input values can be changed in a given range for plane speed (u), for the wind speed (v) and its direction (see Fig. 1), and the new results will be automatically calculated. This provides an opportunity for analysis and comparison of results obtained for different initial values. To do this using pencil and paper with different initial values is both frustrating and time consuming (and does not seem to lead to connections in the heads of students).

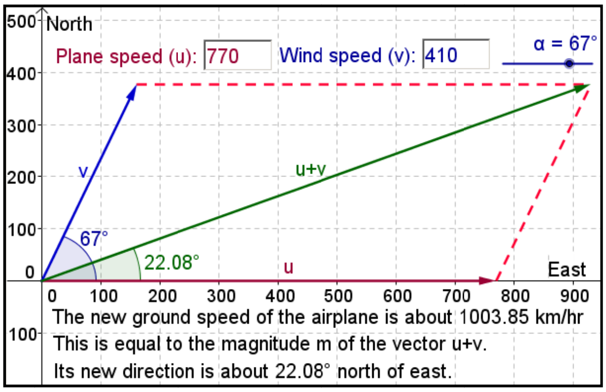

Fig. 1 Application of vectors in navigation: Solution with GeoGebra to example 1.

No.	Name	Definition	Value
1	Number u		u = 770
2	Number v		v = 410
3	Angle α		α = 67°
4	Vector u_1	(u, 0)	u_1 = (770, 0)
5	Point B	u_1	B = (770, 0)
6	Point A		A = (0, 0)
7	Point B'	B rotated by angle α	B' = (300.86, 708.79)
8	Angle β	Angle between B, A, B'	β = 67°
9	Vector v_1	(v cos(α), v sin(α))	v_1 = (160.2, 377.41)
10	Point C	v_1	C = (160.2, 377.41)
11	Line b	Line through B with direction v_1	b:-377.41x+160.2y=-290603.38
12	Line c	Line through C with direction u_1	c: y = 377.41
13	Point D	Intersection point of b, c	D = (930.2, 377.41)
14	Vector w	Vector[A, D]	w = (930.2, 377.41)
15	Angle γ	Angle between B, A, D	γ = 22.08°
16	Segment e	Segment [C, D]	e = 770
17	Segment f	Segment [B, D]	f = 410
18	Number m	Length of w	m = 1003.85
19	inputBox1	InputBox[u]	inputBox1
20	inputBox2	InputBox[v]	inputBox2

Fig. 2 Construction protocol with GeoGebra for Example 1.

The solution of above problem using GeoGebra is uploaded to GeoGebra Tube and is available at: http://www.geogebratube.org/material/show/id/4849.

The second example elaborates the application of vectors in physics:

Example 2 [7]: A 50-N weight is suspended by two wires. Find the forces F1 and F2 acting on the wires if the angles of the wires to the horizontal are 55° and 30°.

To solve Example 2, students have to know that the forces in physics are represented as vectors. Again, they need to know right-triangle geometry and its algebra, which is trigonometry. In the GeoGebra simulation, the student can dynamically change the weight of the suspended body and angles that the wires make with the horizontal beam (Fig. 3).

By moving the sliders, a wide range of initial values can be obtained. Students can read the resulting magnitudes and force vectors from the formulas as part of the computer simulation of the problem and work backwards and forwards to solve other types of problems, e.g. a 35N weight is suspended by two wires. The wire on the right makes an angle of 70° with the horizontal and the force acting on the left wire is F1 = 13.7 N, (see Fig. 4). This gives the student a basis for making comparisons and drawing conclusions.

The solution of example 2 using GeoGebra is uploaded to the GeoGebra Tube at: http://www.geogebratube.org/material/show/id/4861.

5. Conclusions

The research done in this paper has a two-fold purpose. The first is to show how the free and open source dynamic mathematics software GeoGebra can be actively used by teachers and students in visualizing, connecting and understanding mathematical concepts and in improving problem solving skills. This is illustrated by the application of this concept to vectors.

The mathematical concept of vectors is widely used in many scientific areas. It is obvious that vectors are important not only for educational purposes, but also for a number of real-life science problems. Numerous studies have shown that some undergraduate students still have difficulties with the concept of vectors and especially with the usage of vectors in different scientific areas, as physics, mechanics, engineering, navigation etc.. Difficulties mainly result from the different representation of vectors in a variety of applications.

The two specific examples serve as an illustration of how this type of problems may be closer to students. Software simulations can be developed by teachers but also by students under the supervision of the teacher, which is a great opportunity for them to learn the basic mathematical rules needed to solve specific problems.

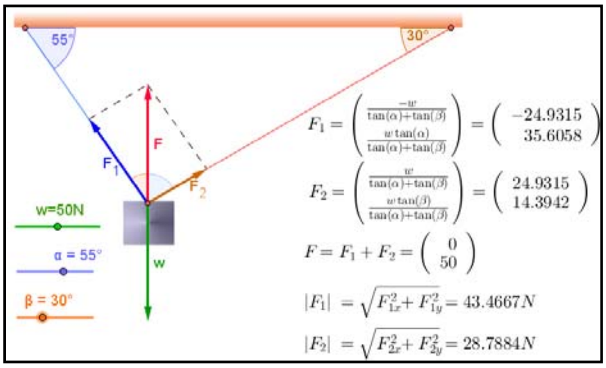

Fig. 3 Application of vectors in physics: Solution with GeoGebra to Example 2.

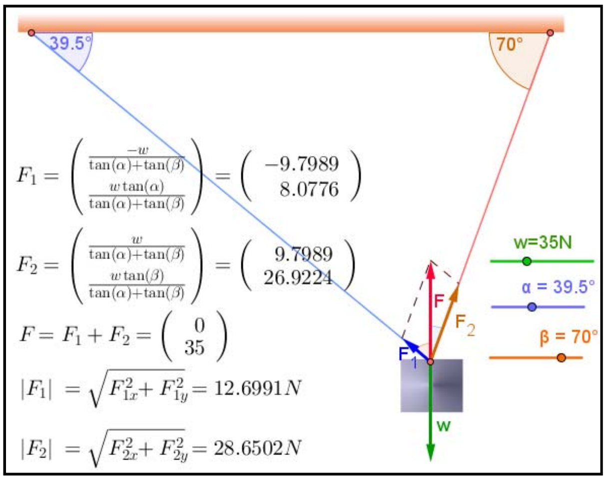

Fig. 4 Different solutions for different initial values in Example 2.

Simulations made with GeoGebra, provide better visualization of problems, the ability to compare results obtained for different initial values and open space for discussion between teacher and students and between students themselves.

The advantages of this approach in the solution of real-life math problems are obvious. Students learn mathematics in a more interesting way. They became active participants in the process of learning and problem solving. By creating GeoGebra applets they connect algebra and geometry; by using the applets they can connect how different input results in different output and these connections build understanding.

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Computer Technology and Application 4 (2013) 459-464

Research on the Activity Frame Work of Using Visual Thinking Tools

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Received: September 4, 2013 / Accepted: September 11, 2013 / Published: September 25, 2013.

Abstract: The development of high order thinking has been considered as a national priority of learning. By using three iteration action research in six elementary schools in Guangzhou, China for about 1 year and a half, we found that visual thinking tools can improve students' high order thinking ability and change the traditional teaching method. By using this activity frame work, the teachers can better understand what are the students thinking about and the students can use the thinking tools to help themselves solve complex problems and discuss with other people. The reason we do this research is to improve the high-order thinking ability of primary student. In this paper, we summarize an activity frame work of using visual thinking tools to improve students thinking ability. And the frame work can be divided into three stages: preparatory stage, implementation stage and assessment stage. And different stage has different activity. Though this activity frame work is not perfect enough, we will improve it in our future study.

Key words: Activity frame work, thinking tool, thinking ability.

1. Introduction

21st century can be called as a century of tremendous changes in social, economic and cultural fields. Accordingly, the most important goal of education in this century should be nurture learners that are ready to face the changing society and complexity of information explosion period. Consequently, the development of high-order thinking has been considered as a national priority of learning [1]. When we think about how to achieve this goal, we face several problems. The first one is that thinking is an abstract thing; are there some certain ways to lead the students to think more deeply by using the visual thinking tools? The second one is if there are certain strategies, could we summarize some positive ones and develop them into an activity frame work? And that is why we use thinking tools during the teaching process.

In this paper, we analyze the difference of the thinking process by changing the activity process, and then improve the activity frame work. The experimental results prove that the frame work can improve students' thinking ability. The paper is organized as follows: Section 2 introduces research methodology; Section 3 states and analyzes the data and Section 4 gives conclusions.

2. Research Methodology

Thinking skills is one of the most important elements in learning process, and research has widely provided evidence for the integration of thinking skills into subject instruction [2]. Therefore, we have some experiments in six elementary schools of Guangzhou, China by action research method (Table 1). We use different thinking tools [3] in the class, such as venn-diagram, PMI (Plus, Minus, Interest) [4] etc..

And then we analyze the video by IFIAS (improved Flanders interaction analysis system) and video clips.

3. Data and Analysis

After we use the visual thinking tools in the primary school in Guangzhou, China for one year, and depending

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Table 1 The situation of six experimental schools.

	Experimental School	Teachers	Students
First Round (2012.8-2013.8)	Yunshan Primary School	2	65
	Zhongshan Road West Primary School	2	65
	Xining Primary School	3	64
Second Round (2013.4-2014.4)	Peizheng Primary School	12	Grade 4-6
	South China normal University Affiliated Elementary School	10	Grade 4-6
	Dexing Elementary School	17	Grade 4-6

on the analysis of some excellent cases of PETA, we summarize a preliminary activity frame to improve students' high order thinking ability by using visual thinking tools.

3.1 Iteration 1 and Its Problems

In the first iteration, we built up an instructional flow depend on the problem-based learning [5] (see Fig. 1).

After several months, we analyze the video by IFIAS and video clips (Table 2), and then compare the works of the students, and we found that:

The student could not choose a proper thinking tool from too much ones.

Some students did not understand and felt interesting of the question they be asked to solved.

We found that the communication between team rarely.

The last and also the most important one, the students could not finish the thinking tools very well, in other word, the student could not solve the questions very well.

3.2 Iteration 2 and Changes

We change the instructional flow (see Fig. 2), and try it again in the elementary school, at this time we found that:

(1) The students understand the problem better and they can share the opinion with other team;

(2) But the students did not know why they will research this question. Did they just to compare or just to collect some information about this question?

(3) The students divide into several groups, maybe it can improve the students' collaborative ability, but at the same time, some group-member did not active part in it.

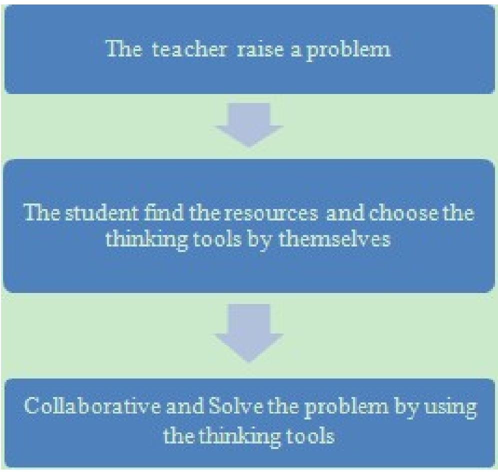

Fig. 1 Instructional flow in the first iteration.

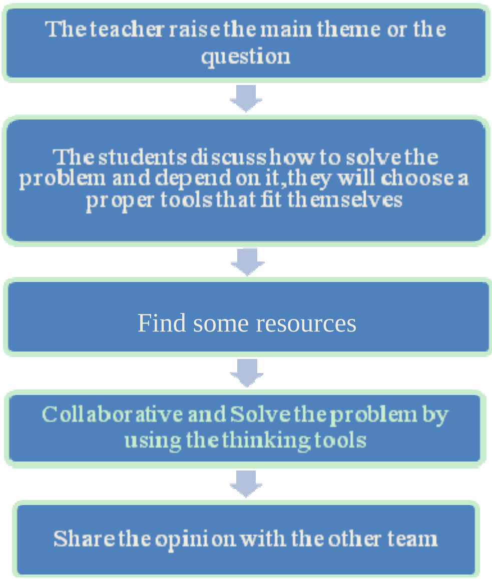

Fig. 2 Instructional flow in the second iteration.

3.3 Iteration 3 and the Activity Frame Work.

We summarize a preliminary activity frame work (see Fig. 3) which is useful to promote students' high-order thinking ability and we will improve this activity framework in the later research.

Table 2 Analyzing video by IFIAS.

Every 3s																				
1min	6	6	9	6	6	6	6	5	5	6	6	6	6	6	6	6	4	9	4	4
2min	4	9	3	9	3	5	3	3	3	3	3	3	4	14	9	9	3	3	6	7
3min	7	6	6	7	7	7	7	7	7	7	6	6	6	7	7	7	7	7	7	7
4min	13	7	13	12	7	7	7	12	12	12	12	12	12	12	7	13	12	12	12	12
5min	12	12	12	7	12	12	12	12	12	12	12	12	12	12	12	2	2	12	12	12
6 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
7 min	12	12	12	12	12	12	6	6	6	12	12	12	12	12	12	12	6	13	6	16
8 min	16	3	3	3	6	2	13	13	13	12	12	12	12	12	12	12	12	12	11	3
9 min	3	7	7	12	12	12	12	12	12	12	12	12	12	11	11	3	2	3	12	12
10 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	7	7	12
11 min	16	16	16	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	12	12
12 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
13 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
14 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
15 min	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
16 min	15	15	15	15	15	15	15	15	15	15	15	15	15	7	15	15	15	15	15	15
17 min	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
18 min	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
19 min	15	15	15	15	15	15	15	15	15	15	7	7	7	7	7	7	7	4	10	10
20 min	16	16	7	16	16	13	10	10	10	10	10	10	10	10	10	7	4	4	9	9
21 min	9	9	9	9	10	10	10	10	10	10	4	4	4	4	4	9	9	9	9	9
22 min	2	2	2	2	2	7	7	13	13	16	16	10	10	10	10	13	10	10	10	10
23 min	10	10	10	10	10	7	4	4	9	9	4	13	9	9	9	9	9	9	9	5
24 min	5	2	7	2	13	6	6	6	7	7	7	7	7	13	7	7	7	7	7	7
25 min	13	7	7	7	7	7	7	7	7	13	13	13	13	13	13	7	7	7	13	13
26 min	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
27 min	13	13	13	13	13	13	13	7	13	13	13	13	13	13	13	13	13	13	13	13
28 min	12	12	12	12	7	13	13	13	7	7	5	5	9	9	9	9	9	10	6	2
29 min	6	6	6	7	6	6	6	6	6	6	6	7	13	12	12	12	12	12	12	12
30 min	12	12	12	12	12	12	12	12	12	12	12	12	12	7	12	12	12	12	12	12
31 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
32 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
33 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
34 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
35 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
36 min	12	12	12	12	12	12	12	12	12	12	12	12	12	12	7	7	7	13	6	6
37 min	6	6	6	6	13	13	17	10	10	10	10	10	10	10	13	10	10	10	5	10
38 min	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6	4	4	9	9	9
39 min	4	9	9	9	2	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6
40 min	6	6	7	7	7	7	7	13	13	13	13	13	7	7	7					

Depending on the analysis of some excellent cases of PETA, we summarize a preliminary activity frame to improve students' high order thinking ability by using visual thinking tools.

3.3.1 Preparatory Stage

In the preparatory stage, the elementary teachers establish the teaching content and define the instructional objectives. Then according to the content and objectives, the teacher designs a question or task and prepares some resources. In this session, the most important thing is to design a proper question or task depending on the goals that you want to achieve. In PETA, the students are about

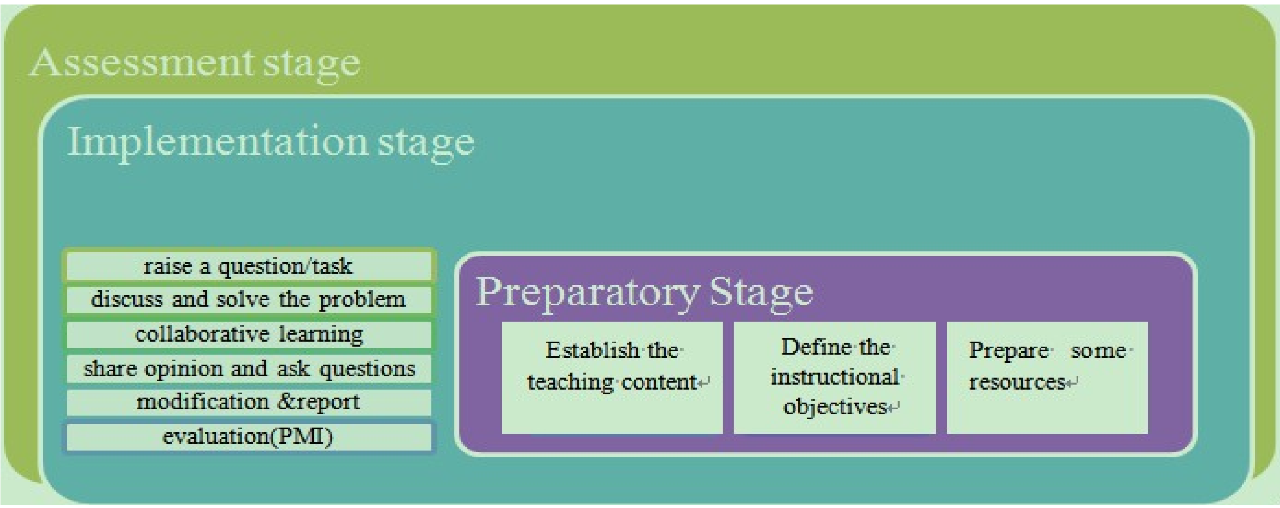

Fig. 3 Preliminary activity frame.

11 to 12 years old; sometimes they could not choose a proper thinking tool, so another thing they think about is which thinking tool needs to be given to the students.

3.3.2 Implementation Stage

The implementation stage is the most important stage of this activity frame. It includes the following six parts:

(1) Put forward a learning problems or tasks, establish the thinking space to the students and ensure them understanding the objectives of this course;

(2) Discuss and solve the problem. The teacher provides some learning resources, and the students also can find some resource including the relevant network resources, multimedia resources, such as books and materials and photos by themselves. Then the students may find the problem or ask questions, and form their point of view;

(3) Use thinking tools to begin group collaborative learning. The teacher will introduce several related thinking tools and the students can choose some of them to use and answer questions or solve the problem by finish the thinking tools;

(4) The students will share their opinion and ask questions cross group. In this part, student can communicate with other group and find the disadvantage and advantage (see Fig. 4);

(5) Modification and report. After that, students will modify their thinking tools and then give a presentation about it;

(6) At last, the students may use the PMI Diagram or Pyramid Sheet to evaluate themselves and other group.

3.3.3 Assessment Stage

In the assessment stage, we will assess the teaching effectiveness with the teacher and try to improve our instructional method by the following ways:

- Analyze the content of the student work;
- Analyze the content of PMI or other evaluating tools;
- Analyze the teaching video;
- Design a questionnaire survey;
- Interview teachers and students.

4. Conclusions

After practiced in the primary school in Guangzhou for one year, we found that by using this activity frame work (see Fig. 5), students can improve themselves' high order thinking ability. The traditional teaching methods have changed. The teachers can better understand what the students are thinking about and the students can use the thinking tool to help themselves solve complex problem and discuss with other people. Of course, we know that the instructional method we said about is not perfect enough. We will try our best to improve it in the later research.

The work is supported by the Scientific Research Foundation of Graduate School of South China

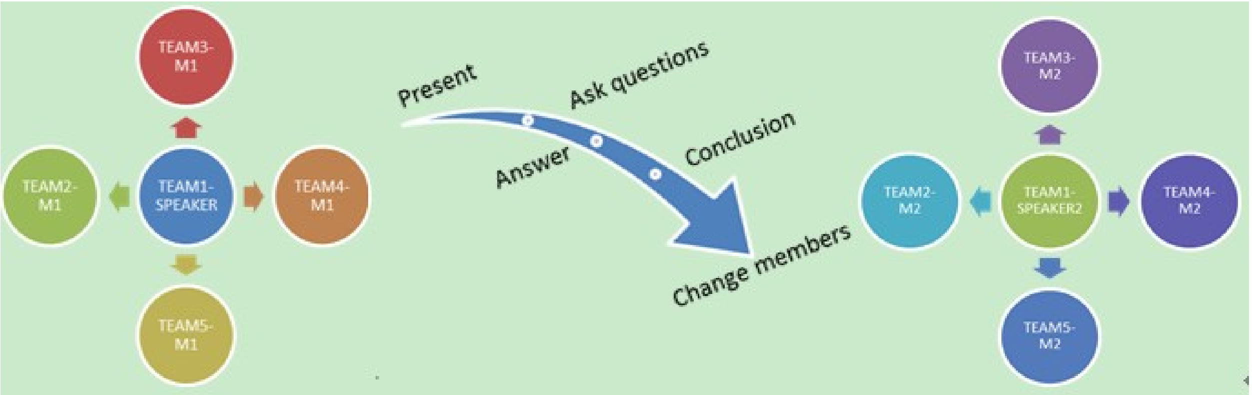

Fig. 4 Preliminary activity frame.

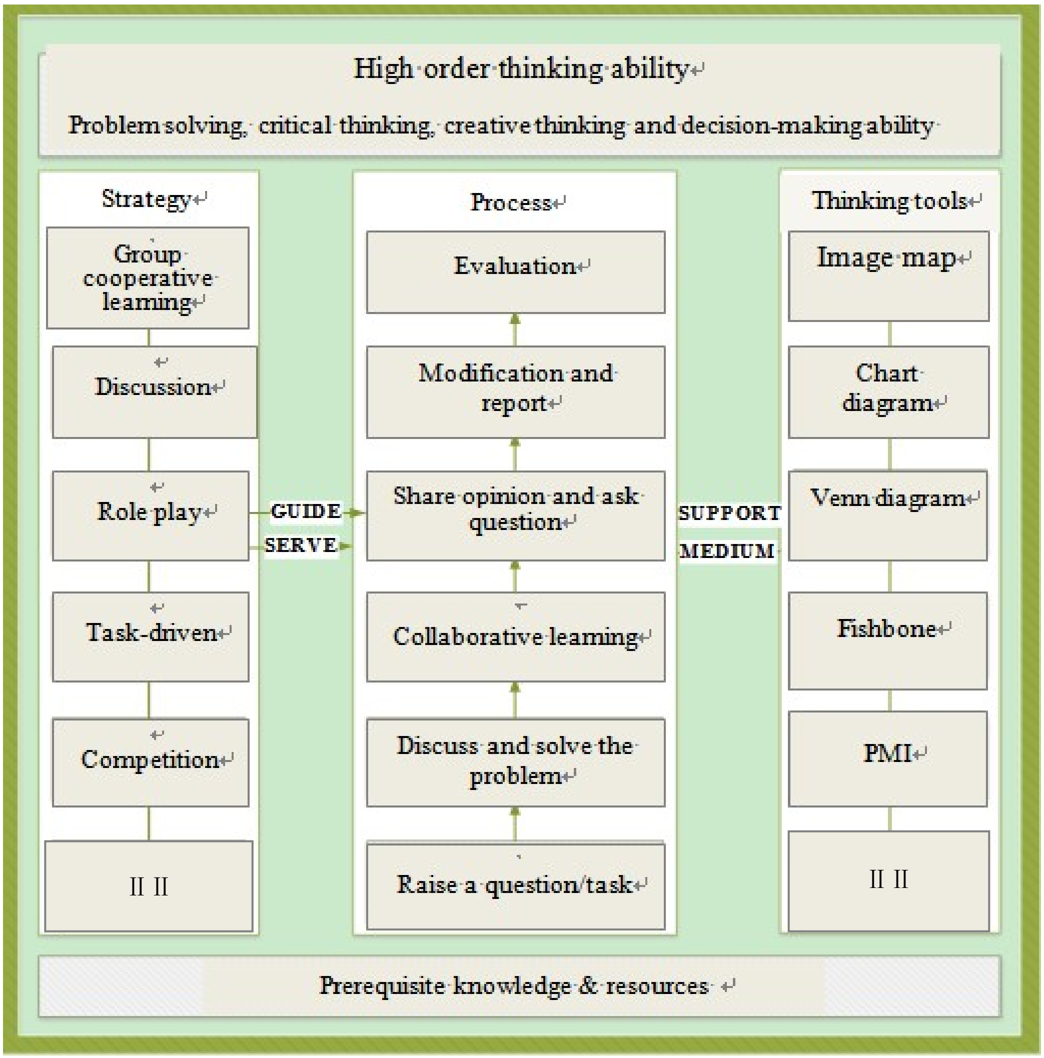

Fig. 5 Activity frame work of using visual thinking tools.

Normal University.

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Computer Technology and Application 4 (2013) 465-474

Spectroscopic Multicomponent Analysis Using Multi-objective Optimization for Variable Selection

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Received: September 4, 2013 / Accepted: September 10, 2013 / Published: September 25, 2013.

Abstract: The multiple determination tasks of chemical properties are a classical problem in analytical chemistry. The major problem is concerned in to find the best subset of variables that better represents the compounds. These variables are obtained by a spectrophotometer device. This device measures hundreds of correlated variables related with physicochemical properties and that can be used to estimate the component of interest. The problem is the selection of a subset of informative and uncorrelated variables that help the minimization of prediction error. Classical algorithms select a subset of variables for each compound considered. In this work we propose the use of the SPEA-II (strength Pareto evolutionary algorithm II). We would like to show that the variable selection algorithm can selected just one subset used for multiple determinations using multiple linear regressions. For the case study is used wheat data obtained by NIR (near-infrared spectroscopy) spectrometry where the objective is the determination of a variable subgroup with information about E protein content (%), test weight (Kg/Hl), WKT (wheat kernel texture) (%) and farinograph water absorption (%). The results of traditional techniques of multivariate calibration as the SPA (successive projections algorithm), PLS (partial least square) and mono-objective genetic algorithm are presents for comparisons. For NIR spectral analysis of protein concentration on wheat, the number of variables selected from 775 spectral variables was reduced for just 10 in the SPEA-II algorithm. The prediction error decreased from 0.2 in the classical methods to 0.09 in proposed approach, a reduction of 37%. The model using variables selected by SPEA-II had better prediction performance than classical algorithms and full-spectrum partial least-squares.

Key words: Multi-objective algorithms, variable selection, linear regression.

1. Introduction

Spectroscopic multi-component analysis is a subfield from quantitative chemical that cares of the concentration determination of one or several substances present in a sample. Knowing the composition of a sample is very important and several ways have been developed to make it possible, like gravimetric and volumetric analysis. Spectrocopic multi-component analysis is an analytical technique that produces spectra of the molecules comprising a sample of material. The spectra are used to determine the elemental composition of a sample and to elucidate the chemical structures of molecules and other chemical compounds. The spectrophotometric technique measure the interaction between the object in analysis and radiated energy supported by Lambert-Beer law [1, 2]. The sample receives a radiation and the absorbed energy could be measure by spectrophotometer and related with the propriety concentration [3].

To obtain the concentration of entire sample, it is necessary to radiate different wavelengths simultaneously. In this scenario, normal wavelengths are overlapping and consequently two or more signals are sending the same information. In algebra terms, the waves are overlapping means high correlation among

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variables and can induce to mathematical problems in the regression model process [4].

Let a sample including two absorbances (A and B) with spectral overlapping $\lambda(1)$ and $\lambda(2)$, is possible to get y_A and y_B like as

$$\begin{aligned} x(\lambda_1) &= k_A(\lambda_1)y_A + k_B(\lambda_1)y_B \\ x(\lambda_2) &= k_A(\lambda_2)y_A + k_B(\lambda_2)y_B \end{aligned} \tag{1}$$

$$\begin{aligned} \begin{bmatrix} x(\lambda_1) \\ x(\lambda_2) \end{bmatrix} &= \begin{bmatrix} k_A(\lambda_1) & k_B(\lambda_1) \\ k_A(\lambda_2) & k_B(\lambda_2) \end{bmatrix} \begin{bmatrix} y_A \\ y_B \end{bmatrix} \\ \begin{bmatrix} y_A \\ y_B \end{bmatrix} &= \begin{bmatrix} k_A(\lambda_1) & k_B(\lambda_1) \\ k_A(\lambda_2) & k_B(\lambda_2) \end{bmatrix}^{-1} \begin{bmatrix} x(\lambda_1) \\ x(\lambda_2) \end{bmatrix} \\ y_A &= b_A(\lambda_1)(\lambda_1) + b_A(\lambda_2)(\lambda_2) \\ y_B &= b_B(\lambda_1)(\lambda_1) + b_B(\lambda_2)(\lambda_2) \end{aligned} \tag{2}$$

In general terms, the multivariate model is given by

$$y = x_0 b_0 + x_1 b_1 + \cdots + x_{J-1} b_{J-1} + \varepsilon \tag{3}$$

Or, in matrix notation

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \tag{4}$$

with $\mathbf{x} = [x_0\ x_1 \cdots x_{J-1}]$ is the vector of measured values, $\boldsymbol{\beta} = [b_0\ b_1 \cdots b_{J-1}]^T$ is the vector to be determined and ε is a part of random error.

In the case of i samples are available with wavelength, we can arrange in pairs $(x_i, y_i) \in \Re^J \times \Re$ like as

$$\mathbf{Y} = \begin{bmatrix} y_1^a \\ y_2^a \\ \vdots \\ y_i^a \end{bmatrix} \mathbf{X} = \begin{bmatrix} x_1^1(\lambda_1) & \cdots & x_1^j(\lambda_n) \\ x_2^1(\lambda_1) & \cdots & x_2^j(\lambda_n) \\ \vdots & \ddots & \vdots \\ x_i^1(\lambda_1) & \cdots & x_i^j(\lambda_n) \end{bmatrix} \tag{5}$$

where, $x_i^j(\lambda_n)$ is the $i-th$ sample of object in the wavelength λ_n and y_i^a is the concentration of a in the $i-th$ sample. Where the relation between the absorbance and concentration can be estimated by a coefficient matrix $\boldsymbol{\beta}$ that multiply $\mathbf{X}$ for obtaining $\hat{\mathbf{Y}}$ estimate. The matrix $\mathbf{X}$ and $\mathbf{Y}$ are divided in $\mathbf{X}_{cal}$ and $\mathbf{Y}_{cal}$ for obtaining the coefficient matrix $\boldsymbol{\beta}$ and $\mathbf{X}_{test}$ and $\mathbf{Y}_{test}$ are used to test the accuracy of prediction model. The coefficients $\boldsymbol{\beta}$ can be obtained by linear regression model according the Eq. (6).

$$\boldsymbol{\beta} = (\mathbf{X}_{cal}^T \mathbf{X}_{cal})^{-1} \mathbf{X}_{cal}^T \mathbf{Y}_{cal} \tag{6}$$

and $\hat{\mathbf{Y}}$ can be estimate like as

$$\hat{\mathbf{Y}} = \mathbf{X}_{\text{test}} \boldsymbol{\beta} \tag{7}$$

The problem happens because the devices have been developed to more accurately measure the absorbance, generating a lot of variables. As a consequence there are more wavelengths (variables) than samples (equations), in the case study of this work for example, we have 775 variables and 389 samples in $\mathbf{X}_{cal}$ matrix using a device not much modern. The most modern devices generate thousands of variables. In the Eq. (6), if the number of variables is major than the number of sample, the inversion is not possible or ill-conditioned. One solution is the use of variable selection algorithms like as genetic algorithm to choice a variable subset not redundant and without collinearity from the original set or the use of new variables obtained from linear transformations like as PLS algorithm.

The literature about this problem [5-8] indicates that the genetic algorithm select a number of variables lager than classical methods like as PLS algorithm and SPA. In this sense we propose the use of a multi-objective formulation to variable selection problem. We use the error of prediction and the number of variables in the fitness evaluation method. Like as discuss in Filhoet. Al. [9], the multi-objective formulation can improve the regression model generalization ability. In the Section 3, we show that the use of just error prediction can guide the genetic algorithm for a model with excess of variables and low generalization power. Additionally, a decision maker method based on statistical test for choice a final solution from the Pareto front is proposed.

2. Background

2.1 Multicollinearity Problem and Variables Selection

The existence of linear correlation between two or more independent variables in a multiple regression model is defined as multicollinearity [10]. This problem may cause difficulty with the reliability of the estimates of the model coefficients and difficulty in understanding the values obtained in response variable

[9, 10].

In prediction problems when the regression model have many variables, the larger part can contribute little or nothing to prediction precision, therefore, select a reduced set with the variables that do influence positively in the regression model is crucial [10]. To define a smaller set of independent explanatory variables to be included in the final regression model is a frequent problem in regression problem. The problem of determining an appropriate equation based on a subset of the original set of variables includes the criterion used to analyze the variables and select a subset and to estimate of the coefficients in the Eq. (6).

According to Miller [11], the reasons for using only some of the available or possible predictor variables include:

(1) To estimate or predict at lower cost by reducing the number of variables on which data are collected;

(2) To predict accurately by eliminating uninformative variables;

(3) To describe a multivariate data set parsimoniously;

(4) To estimate regression coefficients with small standard errors (particularly when some of the predictors are highly correlated).

The proposed strategy to the problem of variables selection for MLR (multiple linear regression) is the use of GA (genetic algorithm) to solve the multicollinearity problem, reduce cost by reducing the number of variables and minimize the residuals errors.

2.2 Classical Methods for Variable Selection in Calibration Problems

There are three classical algorithms for variable selection in calibration problems: the SPA, GA and PLS [7]. The SPA and GA works in the original domain of variables whereas PLS instead of finding hyperplanes of minimum variance between the response and independent variables, it finds a linear regression model by projecting the predicted variables and the observable variables to a new space combining new variables from PCA (principal component analysis).

The SPA is a forward variable selection technique designed to minimize collinearity problems in MLR [12]. SPA comprises two main phases: The first consists of projection operations carried out on the matrix $\mathbf{X}_{cal}$. These projections are used to generate chains of variables. Each element in a chain is selected in order to show the least collinearity with the previous one;in the next phase the candidate subsets of variables are evaluated according to the RMSEP (root mean square error of prediction) (Eq. (8)) predictive performance in the MLR model. The RMSEP evaluates how much the concentration predicted by the model approximates from the expected concentration.

$$\text{RMSEP} = \frac{\sum_{i=0}^{N} (\hat{y}_i - y_i)^2}{N} \tag{8}$$

Where, $\hat{y}_i$ is the predicted value obtained by Eq. (7), y_i is the real value of the concentration and N is the total number of samples.

The RMSEP guides the evaluation of subset of variables used in the calibration model and allows us to chose models more suitable to prediction. In this sense this measure is used also in fitness function of genetic algorithm.

The last results of multivariate calibration literature show that the SPA-MLR has the better results in terms of RMSEP and parsimony (number of variables selected) when compared with the classical genetic algorithm and PLS [12-15]. However in this work we proposed a new implementation of GA that include the use of multi-objective fitness.

3. Multi-objective Formulation of Variable Selection Problem

The classical genetic algorithm is designed to minimize the same function of SPA, that is, the Eq. (8). However, as soon as the RMSEP reduce, more variables are included in the model. In Lucena [14], we demonstrate that RMSEP and the number of variables are conflicting goals. In spite of the RMSEP is reduced as soon as more variables can be included in the model. On the other hand if the number of variables is lager, the Eq. (6) has bad condition and consequently bad generalization in new samples. In this sense we proposed the multi-objective formulation in the genetic algorithm where the first objective is minimize the Eq. (8) and the second objective is the minimization of number of variables selected.

We proposed a multi-objective formulation of the variable selection for multivariate calibration problem. In special, we use three algorithms: NSGA-II (non-dominated sorting genetic algorithm II), (SPEA-II) and epsilon dominance EV-MOGA (multi-objective evolutionary algorithm) algorithms, developed by Deb et al. [16], NSGA-II, as the first NSGA version, implements the dominance concept, classifying population in fronts accordingly to its dominance level [17]. The best solutions of each generation are located at the first front while the worst are located at the last front. The process of classification occurs until all population individuals are located at a front. Finalized this process of classification, individuals belonging to first front are non-dominated, but dominate individuals from second front and the individuals from the second front dominate the individuals from the third front and so on. The main difference from NSGA-II to a simple GA is the way the selection operator is applied, and this operator is subdivided in two processes: fast non-dominated sorting and crowding-distance. The other operators are applied on traditional way.

SPEA is an extension of the GA for multiple objective optimization problems [8]. It is related to sibling evolutionary algorithms such as NSGA, VEGA (vector-evaluated genetic algorithm) and PAES (Pareto archived evolution strategy). There are two versions of SPEA, the original SPEA algorithm and the extension SPEA-II. The objective of the algorithm is to locate and maintain a front of non-dominated solutions, ideally a set of Pareto optimal solutions. This is achieved by using an evolutionary process to explore the search space and a selection process that use a combination of the degree to which a candidate solution is dominated (strength) and an estimation of density of the Pareto front as an assigned fitness. Algorithm maintains an external population at every generation storing all non-dominates solutions obtained so far. At each generation external population is mixed with the current population. All non-dominated solutions in the mixed population are assigned fitness based on the number of solutions they dominate.

The EV-MOGA algorithm [18-20] is an elitist multi-objective evolutionary algorithm based on the control the content of the archive $A(t)$ where the result of the optimization problem is stored. EV-MOGA tries to ensure that $A(t)$ converges toward an Pareto set, in a smart distributed manner along the Pareto front with limited memory resources. It also adjusts the limits of the Pareto front dynamically and prevents the solutions belonging to the ends of the front from being lost.

3.1 Multi-objective Decision Maker Method

Multi-objective algorithm presents a set of solutions for multi-objective problem at its first front. To help choosing a solution within this set, it were applied the Wilcoxon signed rank test as a multi-objective decision maker method.

The Wilcoxon signed-rank test is a non-parametric statistical hypothesis test used when comparing two related samples on a single sample to assess whether their population means ranks differ [12]. It can be used as an alternative to the paired Student's t-test for dependent samples when the population cannot be assumed to be normally distributed.

Let $\hat{\mathbf{y}} = [y_1^i, y_2^i, \cdots y_N^i]$ $i-th$ estimated vector of protein content and ε, the difference vector between the estimated value $\hat{\mathbf{y}}^j$ and the real value $\mathbf{y}$ and ε^j, the difference vector between the estimated value $\hat{\mathbf{y}}^j$ and the real value $\mathbf{y}$. The decision maker algorithm in the first step choose the chromosome with the less value in the Pareto front calculated from validation set. We like to know if ε^j obtained with K

variables not have significative difference with ε^j obtained with $K-P$ variables. That is, the less variable number without decreasing the ability prediction. The null hypothesis is formulated by a two-sided test of the hypothesis that $\varepsilon^i - \varepsilon^j$ comes from a distribution whose median is zero. That is, the difference cannot be significative.

4. Experiments

Samples are from whole grain wheat, obtained from vegetal material from occidental Canadian producers. The standard data were determined at the grain research laboratory [9, 14, 21, 22]. The data set for the multivariate calibration study consists of 775 VIS-NIR spectra of whole-kernel wheat samples, which were used as shoot-out data in the 2008 international diffuse reflectance conference. Protein content, test weight, WKT and farinograph water absorption were chosen as the properties of interest. Test weight is used as an indicator of general grain quality and is a measure of grain bulk density. Test weight, but not overall grain weight, normally increases during drying. Spectra were acquired in the range 400-2,500 nm with a resolution of 2 nm. In order to remove undesirable baseline features, first derivative spectra were calculated by using a Savitzky-Golay filter with the 2^{nd} order polynomial and an 11-points window [15].

The KS (Kennard-stone) [11] algorithm was applied to the resulting spectra to divide the data into calibration, validation and prediction sets with 259, 258 and 258 samples, respectively. The validation set was employed to guide the selection of variables in SPA-MLR, MONO-GA-MLR, NSGA-II-MLR and SPEA-II-MLR. The prediction set was only employed in the final performance assessment of the resulting MLR models. In the PLS study, the calibration and validation sets were joined into a single modeling set, which was used in the leave-one-out cross-validation procedure.

4.1 Environment and Tools

For executing the NSGA-II-MLR, SPEA-II-MLR, mono-objective GA, SPA and PLS algorithm were used the Matlab software version 7.10 (R2010a). Table 1 shows the configuration for NSGA-II-MLR and SPEA-II-MLR algorithms. MONO-GA-MLR has the same parameters of multi-objective algorithms.

4.2 Results and Discussion

Fig.1 presents the derivative spectra of wheat sample. As can be seen there are several of spectral variables available for selection with different absorbance (λ).

First of all, we describe the results of the classical algorithms PLS, SPA-MLR and MONO-GA-MLR. These results are presented on Table 2. As can be seen the RMSEP are similar for the three algorithms in all of elements studied. However the MONO-GA-MLR uses an expressive number of variables when compared with SPA-MLR. This result can be explained by the fact of MONO-GA-MLR use just one objective, the RMSEP in the validation set. In practice the SPA-MLR is used because it uses fewer variables than MONO-GA-MLR and PLS. Worth noting that PLS uses all original variables to build the new latent variables. The next paragraphs present the results obtained by the proposal algorithms, NSGA-II-MLR and SPEA-II-MLR under 30 executions each.

Fig. 2 shows one of the Pareto front obtained by NSGA-II-MLR (Fig. 2a) and SPEA-II-MLR (Fig. 2b) for test weight concentrations. As can be seen, both algorithms minimized the two objectives, the number of variables and the RMSEP in the validation set. However, the SPEA-II-MLR algorithm has a boundary better distributed in the objectives space. For this property NSGA-II-MLR found solutions with the minimum number of 15 variables, while SPEA-II-MLR found solutions with just 3 variables. These figures also show the decision maker result for both algorithms in this execution.

The selected variables in the chromosome, result of the decision maker, can be observed on Fig. 3. In general, the number of variables is lower in SPEA-II-MLR than NSGA-II-MLR. In spite of SPEA-II-MLR selected

Table 1 Multi-objective algorithms NSGA-II, SPEA-II and EV-MOEA configuration.

	NSGA-II, SPEA-II and EV-MOEA
Population size	100
Generations number	100
Selection operator	Binary tournament
Mutation operator	Flip
Mutation probability	0.5 in the individual and 0.05 in the gene
Crossover operator	Uniform crossover
Crossover probability	0.5 and 1

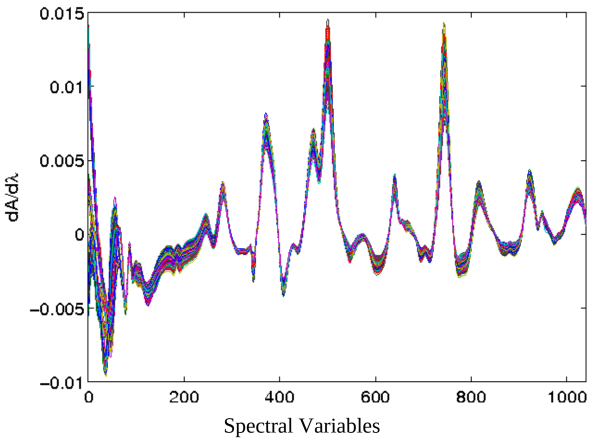

Fig. 1 Derivative NIR spectra of the wheat samples.

Table 2 Results of traditional techniques PLS, SPA-MLR and MONO-GA-MLR.

	Protein content (%)	
	RMSEP	Number of variables
PLS	0.21	15*
SPA-MLR	0.20	13
MONO-GA-MLR	0.21	146
Test weight (Kg/Hl)		
	RMSEP	Number of variables
PLS	1.23	5*
SPA-MLR	1.2	29
MONO-GA-MLR	1.38	112
WKT (%)		
	RMSEP	Number of variables
PLS	2.76	11*
SPA-MLR	1.2	36
MONO-GA-MLR	2.69	157
Farinograph water absorption (%)		
	RMSEP	Number of variables
PLS	2.11	7*
SPA-MLR	2.14	18
MONO-GA-MLR	2.41	96

*Number of latent variables.
Range of protein content in the prediction set: 10.2-16.2% m/m.
Range of test weight in the prediction set: 78.2-84.7 (Kg/Hl).
Range of WKT in the prediction set: 48-73% m/m.
Range of WKT in the prediction set: 53.1-75.6% m/m.

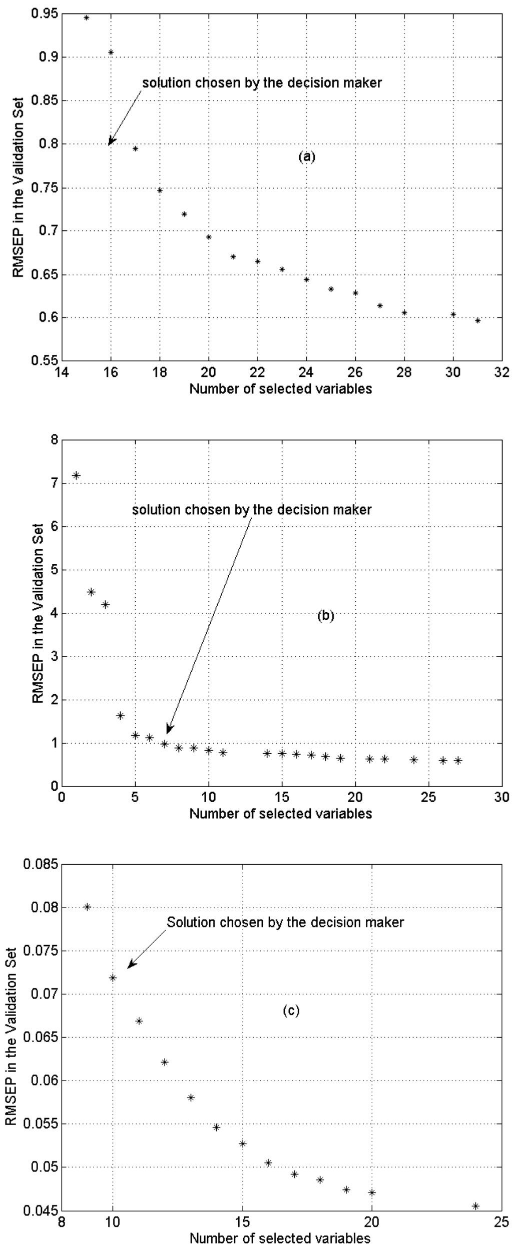

Fig. 2 Pareto front in the NSGA-II-MLR (a), SPEA-II-MLR (b) and EV-MOGA algorithm (c).

less variables, both algorithms cover the same spectral regions. This similarity indicates that these regions are the most promising to use in the spectrophotometer. In practice, this result implies a smaller number of wavelengths measures in spectrophotometer for quantify the test weight property in real samples. For the other properties of interest the results for NSGA-II-MLR and SPEA-II-MLR are similar for those presented in Figs. 2-3.

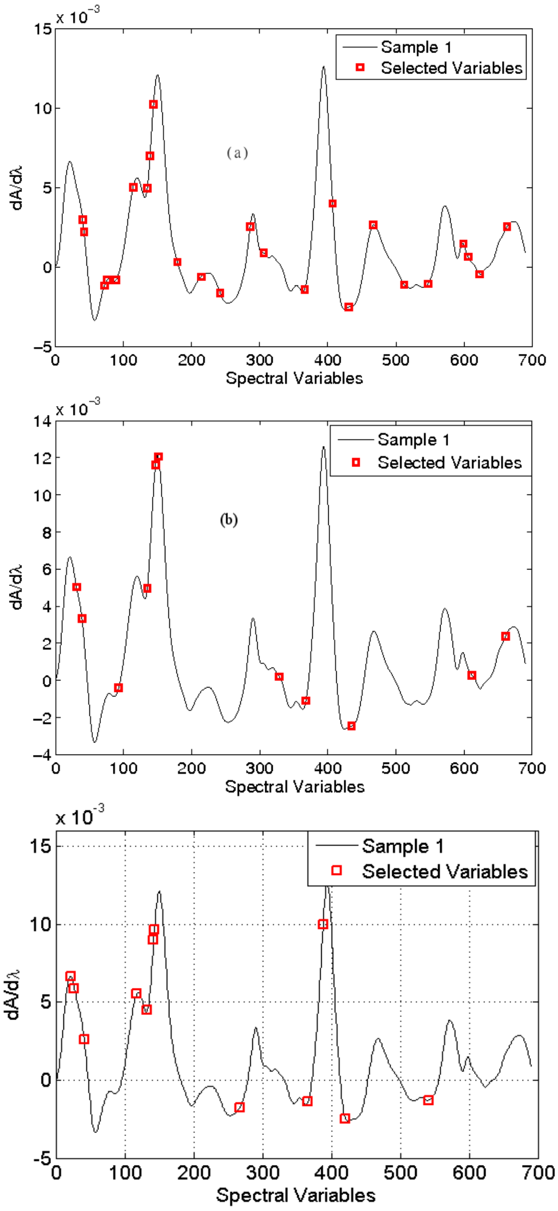

Fig. 3 Variables selected by NSGA-II-MLR (a), SPEA-II-MLR (b) and EV-MOEA algorithm.

The solutions obtained by the decision maker in each of the executions will be used in the next paragraphs in order to calculate the RMSEP measure in the prediction set. Table 3 shows the resume of results of NSGA-II-MLR and SPEA-II-MLR. The results were obtained by 30 executions of each of these algorithms for each property. Worth noting that results refer to solution selected by decision maker in each execution applied in the prediction set. The prediction set was not used at any stage of the proposed algorithms. This set is used to measure the generalization ability of the obtained solutions. As can be seem the NSGA-II-MLR and SPEA-II-MLR had a small difference in RMSEP average. For protein content and test weight NSGA-II-MLR has better RMSEP values than SPEA-II-MLR, but for WKT and Farinograph water absorption SPEA-II-MLR obtained better RMSEP values. However, for all the properties SPEA-II-MLR found solutions with a lower number of variables selected than NSGA-II-MLR.

Analyzing all results obtained by NSGA-II-MLR and SPEA-II-MLR algorithms we infer that SPEA-II-MLR has a best behavior. SPEA-II-MLR selects a fewest number of variables and it has a small difference in RMSEP of NSGA-II-MLR. The few number of variables is important in other applications of calibration problems where the spectroscopy measure can be expensive. In this cases the expert can choose a solution with a prediction error a little high but with few variables.

Now, we compared the results obtained by SPEA-II-MLR with the classical algorithms. First of all, we can see that the multi-objective formulation resolved the problem of excessive number of variables in the mono-objective approach. For example, in the test weight, while the MONO-GA-MLR selected 112 variables with a prediction error of 1.38, SPEA-II-MLR chose just 9 variables with a prediction error of 1.01. And for the WKT, MONO-GA-MLR selected 157 variables with RMSEP of 2.69 while, SPEA-II-MLR selects 9 with a prediction error of 2.19. In comparison with SPA-MLR, SPEA-II-MLR also use a less number of variables in average for all the properties of interest, SPA-MLR uses 13, 29, 36 and 18 variables while SPEA-II-MLR selects 10, 9, 9 and 5, respectively. The average RMSEP result of SPEA-II-MLR was 57% better than PLS and MONO-GA-MLR and 55% better than SPA-MLR. In the test weight property, SPEA-II-MLR was 15.8%, 17.8% and 26.8% better than SPA-MLR, PLS and MONO-GA-MLR respectively. In the WKT property,

Table 3 Results of traditional techniques PLS, SPA-MLR and MONO-GA-MLR. The results are expressed in RMSEP terms in the prediction set.

	NSGA-II-MLR	SPEA-II-MLR	EV-MOEA
Protein content (%)			
Average RMSEP	0.087	0.090	0.0746
Maximum RMSEP	0.129	0.145	0.1257
Minimum RMSEP	0.059	0.068	0.0501
Average number of variables	19	10	15
Maximum number of variables	24	17	85
Minimum number of variables	12	7	8
Test weight (Kg/Hl)			
Average RMSEP	0.76	1.01	0.69
Maximum RMSEP	0.88	1.13	0.90
Minimum RMSEP	0.70	0.89	0.61
Average number of variables	22	9	9
Maximum number of variables	30	10	43
Minimum number of variables	17	7	7
WKT (%)			
Average RMSEP	2.27	2.19	2.04
Maximum RMSEP	2.39	2.45	2.39
Minimum RMSEP	2.19	2.11	1.86
Average number of variables	19	9	10
Maximum number of variables	29	15	59
Minimum number of variables	14	5	7
Farinograph water absorption (%)			
Average RMSEP	2.17	2.10	1.93
Maximum RMSEP	2.39	2.35	2.21
Minimum RMSEP	2.09	2.08	1.81
Average number of variables	12	5	6
Maximum number of variables	16	7	69
Minimum number of variables	9	4	6

the improvement of SPEA-II-MLR in relation SPA-MLR, PLS and MONO-GA-MLR was 11.6%, 17.7% and 15.6% respectively. And finally, in the farinograph water absorption property SPEA-II-MLR was 1.8%, 2.3% and 2.3% better than SPA-MLR, PLS and MONO-GA-MLR, respectively.

Fig. 4 shows the result of prediction of test weight versus the real test weight by the solution of SPEA-II with less RMSEP value. In the ideal case the points are arranged on a straight line. As can be seen, the predicted values are close of real values. In Fig. 5, we can see the result of prediction of protein content using the model with the less RMSEP value. The predicted values are very close of real values using just 13 variables selected by the multi-objective algorithm. In selected variables can be used in practice. The results for the other properties were similar.

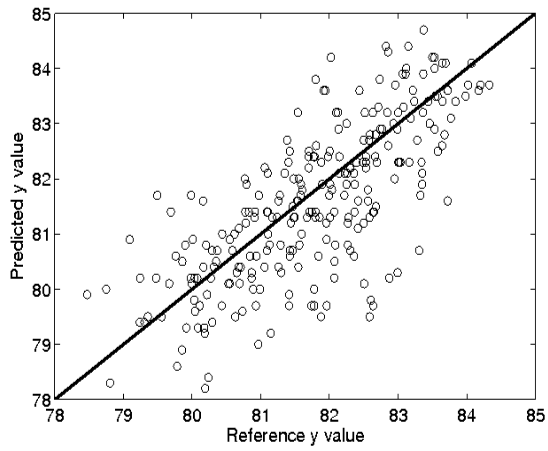

Fig. 4 Comparison between real and predicted test weight by model built by SPEA-II.

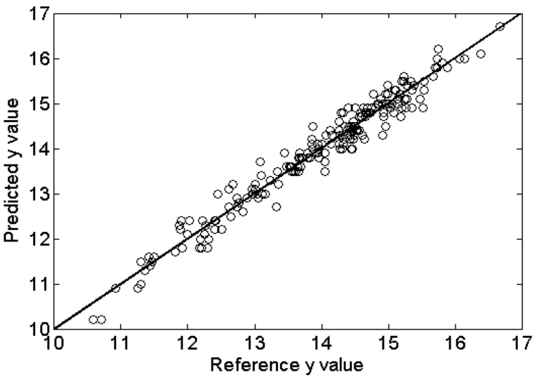

Fig. 5 Comparison between real and predicted protein content by model built by EV-MOEA.

5. Conclusions

In this work, we proposed a multi-objective formulation of variable selection problem in multiple determination problems of chemical properties using NSGA-II-MLR, SPEA-II-MLR and EV-MOEA algorithms. A case study based on chemical properties of wheat was presented. The results obtained showed that the multi-objective formulation resolved the over fitting classical problem of mono-objective formulation. While mono-objective GA formulation use a bigger number of variables with prediction error similar to classical algorithms the multi-objective algorithms use fewer variables with the less prediction error. The results of three multi-objective algorithms were similar, with a slight advantage for EV-MOEA. We can conclude that the main aspect is the proposed multi-objective formulation for the problem independent of the multi-objective algorithm used.

Acknowledgments

The authors would like to thank the foundation support research in the state of Goias (FAPEG) and CAPES, process number 09/2012 and 06/2009, for financial support in this project. This is a contribution of the INCTAA (National Institute of Advanced Analytical Science and Technology) (CNPq-proc. no. 573894/2008-6 and FAPESP proc. no. 2008/57808-1).

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Computer Technology and Application 4 (2013) 475-784

Teaching and Learning on the Internet: A New Model of University, the International Telematic University UNINETTUNO

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Received: September 7, 2013 / Accepted: September 15, 2013 / Published: September 25, 2013.

Abstract: The convergence of telecommunications and computer science, the realization of computer-based networks and the integration of languages, by overcoming space and time constraints, gave rise to the globalization process and to the development of the knowledge society. We are facing a true revolution that is based on the multiplication of knowledge and its corresponding applications, but also on the knowledge codification, memorization and knowledge transfer. The challenges that educational institutions, and the University in particular, are called to face are linked to the fact that classrooms or lecture halls are no longer the only places where one can follow study courses: anybody from anywhere, if he has the required technological equipment and the appropriate materials can build his own environment to carry on his own educational and self-learning process. This is the reason why we need to identify new models of university and psycho-pedagogic theories allowing for the development of new Internet-based teaching and learning models by carrying on research work. This paper describes the university model proposed by International Telematic University UNINETTUNO, rapidly become acknowledged at an international level.

Key words: Technologies trends, distance education, knowledge society, university, innovative, life-long learning.

1. Introduction

This paper illustrates the university model proposed by International Telematic University UNINETTUNO, developed in more than 25 years of theoretical and applied research on teaching and learning technologies.

Facing the challenge of economy and market internationalization processes, of the continuous and progressive process of codification, storage and transfer of knowledge and of functions to automatic and computer-based structures, which enlarge and multiply the possibilities for acquiring information and knowledge and for establishing interactions, the traditional educational systems show their limits worldwide. By now, classrooms or lecture halls are no longer the only places where one can follow study courses; on the contrary, anybody from anywhere, if he has the required technological equipment and the appropriate materials can build his own environment to carry on his own educational and self-learning process [1].

New technologies allow for a direct connection between the university and the user through a simple PC, a tablet or a smart-phone: lessons, multimedia products, databases, self-assessment systems, exams organization. In the "virtual" classrooms, it is possible to reproduce teaching-learning activities as it happens in actual classrooms, but it is also possible to significantly increase the amount of information and start up multiple interactions in real time among individuals belonging to different cultural levels,

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having different traditions and experiences and coming from educational environments of different countries of the world. Physical distances are cancelled and the communication global system allows delocalizing the delivery and use of a globalised knowledge.

The swiftness with which technology evolves, the Internet and satellite information transmission will soon enable even the poorest countries of the world to access the Web. In 2016, according to estimates provided by Cisco Systems [2], there will be 10 billion mobile equipments connected to the Internet for a world population of 7.3 billion of people. This means that, on average, each inhabitant of the world will have more than a set of equipment to connect to the Web. Building schools and universities to take education and training to the poorest countries of the world is important, but not essential. In the present historical era, what is really important is to create quality contents that could contribute to improve the life of each single person.

Given that it triggers educational communication mechanisms that represents a peculiar form of dialogue between professors and students and new interactive modes between information sources and receiver, a technology-based distance teaching model requires the development of theoretical as well as applied research programs according to which it is possible to design and realize psycho-pedagogic and training models aimed at distance teaching and learning. Applied research becomes essential to make that results become the theoretical basis on which to shape psycho-pedagogic and organizational models useful to implement distance teaching and learning processes.

This essay illustrates the psycho-pedagogic model of the International Telematic University UNINETTUNO, derived from the results achieved by several research projects that have been developed by me and my research team over the last 25 years. Most of these research programs were aimed at the construction of a coherent body of theoretical and operational knowledge that gave origin to a complex distance teaching system, based on the use of cognitive and connectionist theories. The results achieved up to now allowed getting a balance between the technical-engineering components and the cognitive, cultural and educational ones, strictly linked to the development of the information technologies and they involved several international-level scientists of various disciplines (technologists, computer scientists, learning psychologists, experts in the various languages). Therefore, research activity that was carried on, was, at the same time, theoretical-experimental, pure and applied. As a consequence, their results enabled to identify new ways for implementing both face-to-face and distance teaching-learning processes that already have a significant impact on the theories related to learning processes, teaching methodologies, distance interaction relationships. Cognitive and connectionist theories are the theoretical foundation on which the whole distance teaching and learning process take place.

The paper is structured as follows: Section 1 gives an introduction; Section 2 describes how changes in pedagogical models derived from new information and communication technologies are implemented in an Internet learning environment; Section 3 and 4 summarize the new teaching (3) and learning (4) methods and models; and Section 5 gives the conclusions.

2. Distance Teaching and Learning Models

Thanks the International Telematic University UNINETTUNO model it is possible to integrate the different didactic-pedagogical possibilities of the various media available and realize, on this basis, a set of open and flexible learning environment that allows:

- Starting, also at distance, new communication relationships between students and professors, promoting the shift from one-way communication (typical of the first distance teaching models) to a two-way real time communication model also available in real time;

• Ending up the one-way communication of knowledge and starting a new line of communication that allows the student to access dynamic knowledge that can be self-enriched by the student and can be made available for other people ;

• Using the PC connected to the Internet as the focus of a system where different contributions from different media converge to allow the creation of a truly integrated and "open" multimedia model. The PC allows transmitting directly from the University to the student's desktop lessons, multimedia products, databases, tutor support, practice work, assessment and self-assessment systems [3].

The International Telematic University UNINETTUNO proposes didactics envisaging synchronic teaching/learning modes where there is unity of time, but not of space as it regards the teaching and learning process as well as diachronic modes, where the educational and training process is no longer linked to the unity of time and space.

2.1 The Internet-based Didactic Portal

2.1.1 Internet for Teaching and Learning

The main educational tool of the International Telematic University UNINETTUNO is the Internet-based learning environment where teaching and learning are carried on in 6 languages—Italian, English, French, Arabic, Greek, Polish—and it allows implementing a new psycho-pedagogic model that is characterized by the shift:

• From teacher's central role to the student's central role;

• From knowledge transfer to knowledge creation;

• From integration between practice and theory;

• From a passive and competitive learning to active and collaborative learning.

This psycho-pedagogic model is characterized by the highest degree of flexibility for the student. By this model, the student can build his own learning path in function of his educational needs and of his skill-level. A learning environment developed in such a way does not limit itself to offer rigidly pre-established courses, but it offers dynamic contents that can be enriched by other contents existing on the Web.

Actually, in the International Telematic University UNINETTUNO, the student is at the centre of the educational process; however he is guided by the new profile of the professor/telematic tutor who has the task of supplying the tools needed to facilitate the networked learning and communication process in a synchronic and diachronic way.

In the Didactic Cyberspace, the students actively participate in the creation of their own learning paths being guided by expert teachers/tutors. This guided path leads the learner into the various virtual places that were designed and in each of them it is possible to implement a training session based on a specific model of communication:

• Through the digitized video lessons, the student uses a linear learning mode which is still linked to a classical teaching mode, but thanks to the modular structure of the contents, the student can exploits the hypertextual modes to study and consult books related to the issues being treated;

• In the virtual laboratory, the student can check and enhance his knowledge according to a "learning-by-doing" mode, being supported "in itinere" by a tutoring system;

• Through the systems of chats, forums, wikis and with the web-based virtual classrooms and on second Life, finally, the student can carry out collaborative learning sharing the phases of the learning process with other students coming from different linguistic and social settings through a web-based meeting.

In each learning environment, it is possible to integrate each single learning mode with the other ones simultaneously and enrich them with various possibilities. The multimedia term is intended in its widest meaning and the learning activity is structured in such a way as to avoid wasting time and confusion and promote the spreading of knowledge though various means:

- From simple to complex (video lesson and intelligent library);
- From theory to application projection (learning by doing in the virtual laboratory);
- From guided exercises to research on the World Wide Web (the Internet);
- From individual study to interactive dialogue between professors and students (collaborative learning through synchronic and diachronic communication and sharing tools) [4].

2.1.2 The Didactic Cyberspace

The main didactic tool is the Internet-based learning environment www.uninettunouniversity.net. In the didactic cyberspace can access various learning environments.

For each delivered course, the student has at his disposal a conceptual map (Fig. 1), a graphical, two-dimension and hypertextual representation, in which the macro-issues included into each course, the lessons included into each macro-issue; clicking on each single lesson, the student can see the issues it contains and what the materials associated to the whole lesson or each single macro-issue that are treated in it.

In UNINETTUNO psycho-pedagogic model, the videolessons play a major role; they are recorded by professors coming from the best universities of Italy and of the world; then, they are digitized and posted online on an interface allowing a hypermedia use. The student can watch the videolessons according to a linear sequence, or decide to control the teaching process by pausing, going backwards or moving along the time-line of a lesson as he likes; and he can use the tools made available on UNINETTUNO portal: by means of the interface designed by UNINETTUNO, the student can surf among the videolessons, moving from one to another, within the same videolessons, using the indexing option that allows him to select a specific sub-issue treated by the video professor and play the video to the second in which the professor starts to treat that specific issue or among the more-in-depth

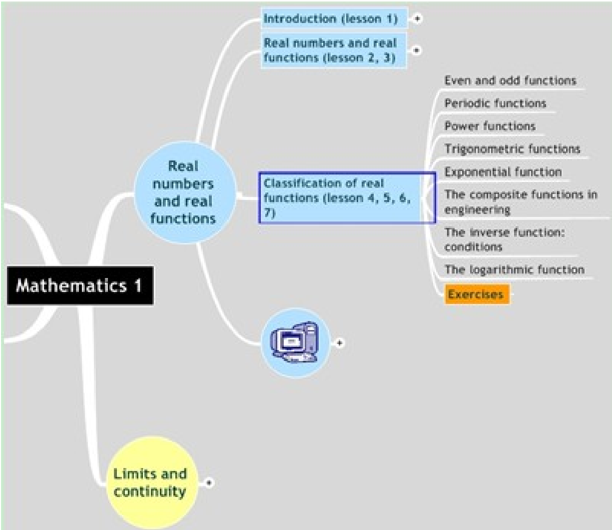

Fig. 1 An example of conceptual map.

materials related to that specific video lesson, by means of the box at the right of it.

In addition, in some specific moments, a bookmark (Fig. 2), a lighting signal highlights or one of the types of more-in-depth study materials listed in the box at the right of the video, indicates to the student that a specific more-in-depth study material associated to what the professor is speaking about in that specific moment of the videolessons. Through this way, the learning process becomes an hypermedia process: the student can access more-in-depth contents suggested in real time by hypermedia bookmarks structured by professors and researchers that allow him directly access to books and articles, that is to say texts, lecture notes, produced essays, selected and made available by professors and tutors, CD-Roms, multimedia materials, photo galleries, films associated to videolessons; bibliographical references and selected lists of websites, collections of references to external materials validated by professors and tutors experts of each single course in scientific terms; exercises and virtual laboratories.

Through exercises and virtual labs, the students have at their disposal materials that will allow them to put into practice the knowledge learnt through the study of training materials described above. The goal is to create a powerful synergy in the virtual laboratory so that theoretical learning and practical problem-solving

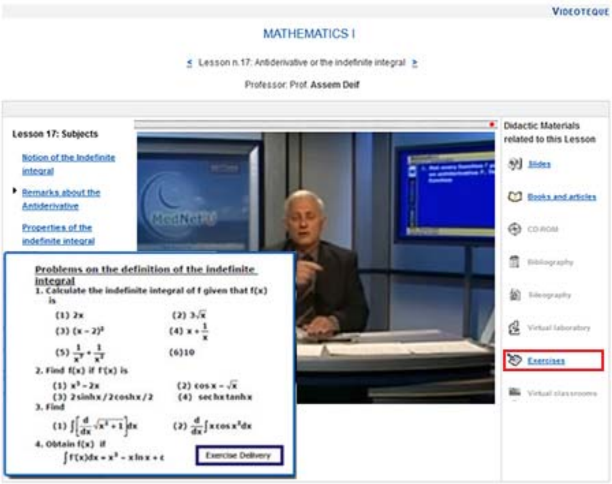

Fig. 2 Videolesson with activated bookmark.

co-exist in the correct ratio and fully integrate each other: the student will be able to think about his experiences in the learning environment, and the abstract principles described by the teacher become motivated, are made operative and can be committed to memory thanks to the problem-solving activities. The exercises available for each course; the self-evaluation exercises allow the student to get an independent feedback, lesson by lesson, on which is the comprehension level gained on the specific subjects that he studied. The progress-check exercises, to be submitted to the professor/tutor through the portal, are assessed by professors who, so doing, will give their feedback and a direct comment on which is the learning progress achieved by the students on the macro-issues for which he is assessed. In the Laboratories, the students can utilize online simulations for benefitting from tools that would be accessed only from excellence research centres, as well as use theoretical knowledge learnt in learning-by-doing activities on materials otherwise not accessible; the professor/tutor supervises and monitors the student's activities, who, once he completes his experience, automatically sends the sheet with the results of his work to the his own tutor.

The International Telematic University UNINETTUNO learning environment gives the student an absolutely active role; all the training materials are made available for this purpose. The student is not left alone, but he is guided by an expert tutor. This is the reason why the portal has a special area called online tutoring. On the Forums, and Wikis, professors, tutors and students discuss about the issues proposed by the professors, they further analyze specific issues, ask questions on key points of the subject being studied. In addition, Professors and Tutors plan synchronic meetings on regular basis in UNINETTUNO virtual classrooms (Fig. 3) in which the students can exchange views with their own colleagues and their professors via chat, video streaming on the Web live or in the virtual classrooms in the UNINETTUNO Island of knowledge on second life.

The student's whole learning process is continuously monitored by the professors and tutors. The students are organized in classes, with a numerosity varying from 20 to 30 students for each class. The organization in classes allows tracing course attendance and the learning progress of each student in quantitative as well as in qualitative terms. In quantitative terms, the tracing system of UNINETTUNO portal (Fig. 4) supplies reports and statistical data on the individual study activities of each student: accesses to the materials of each course, time of use of the videolessons, time spent by each student in studying the texts and training materials associated to the issues treated in the videolessons. In qualitative terms, the teacher/tutor

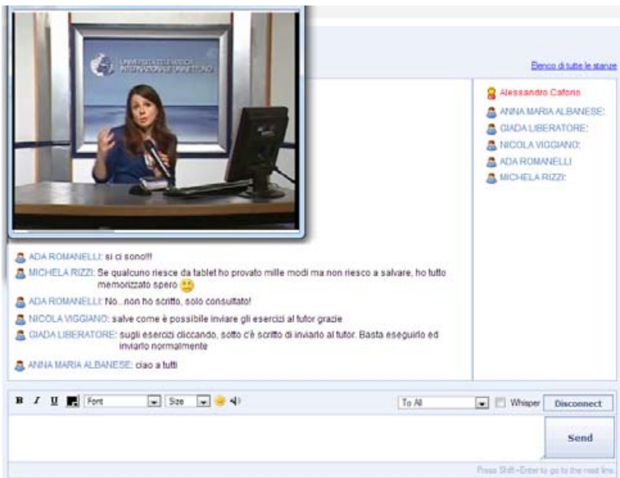

Fig. 3 Collaborative learning environments—virtual classroom UNINETTUNO in live streaming.

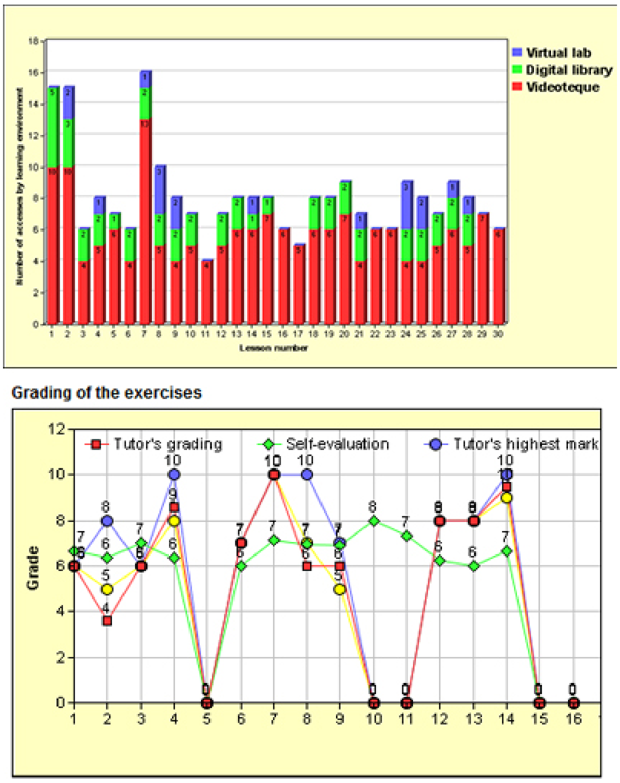

Fig. 4 UNINETTUNO student tracing and reporting system.

has the task of checking the students' learning progress through exercises as well as during meetings taking place in the Virtual Classroom during which the teacher/tutor ask the students questions on the issues dealt in the videolessons and check their comprehension and mastery level of the these issues for each student and including their assessments on a qualitative assessment sheet for each single student.

These data, beside populating the student's sheet that is used by the teacher to decide the admission or not to the exam of the individual student who is required to have attended the course, having watched the videolessons, having taken part to the tutoring activities to be admitted to the final exam, are aggregated and represent a tool for having a feedback on the progress of the whole class. By means of data that are aggregate per class, the teacher-tutor can immediately see whether there any problems shared by the whole class on specific course issues; once he identifies a common problem, he can take measures "in itinere", during the same course delivery period, supplying more-in-depth study texts, moderating a discussion on a forum or planning some meetings on the virtual classroom meant to fill the gap that this feedback system allowed highlights.

3. New Teaching Models

The new model proposed involves a changing of the university teachers' traditional competences. Actually, the professors have to learn how to deliver courses on television, to design multimedia products, online exercises and materials to be put on the website and to guide the students along their self-learning process using non-traditional tools, methods and technologies. The professors have the double function of teaching through the Internet, but at the same time of delivering a learning support activity through the Internet. Designing and producing videolessons changes traditional didactic communication of the professors. In the new didactic model, the professors have to learn a new way of explaining, synthesizing and presenting his knowledge to a virtual student in order to trigger a critical and reflective learning process. The videolesson requires a specific preparatory work and, in order to exploit all the potentials of the tools, the professor has to work with a team of technicians and experts in language of image. We calculated that each hour of videolesson requires from twenty to thirty hours of preparatory work. This, of course, develops in the professors' new communication skills and the use of new languages that area used also to store the results of their own research work. This new training experience has an impact on the way they deliver their lessons also in their traditional academic courses.

In the videolessons, the professor teaches in an interactive way, asks questions to the students; and the students answer and interact with the professors and jointly develop collaborative learning processes. The model of interaction between teacher and students applies the Socratic pedagogical theories that are based on the fundamental assumption that envisages not a teacher-learner unidirectional kind of teaching, but an active participation of the learner in his own training process; the teacher guided the student to a customized learning path continuously urging him to play an active role in the construction of his own knowledge. A construction made of continuous and intense dialogues, exchanges of questions and answers allowing the direct confrontation of opposite assumptions. The "maieutic" art, the Socratic Method, based on dialectics is an active and interactive learning method. Socrates is beside his learner, assists him, motivates him, encourages him not to stop learning praising his work when it is praiseworthy and stimulating him when he faces some difficulties. Interactivity develops in the dialectic way: the teacher against the learner, the teacher with the learner has a single objective: the conquest of knowledge [5]. The telematic teacher/tutor proposes some issues and illustrates his theses on forums; he discusses them with his learners in the virtual classroom and sets the objectives to be met; the learners study them, analyze them, re-interpret them, revitalize them and enrich them with new ideas, new knowledge; they jointly produce new study issues that become topic of discussion in further interactive virtual classrooms. The learners become active constructors of new knowledge.

3.1 "One-to-One" Scenario (Learning in a Single Mode)

In this scenario, by means of chats and videochats, the teacher-tutor supports the student during his exploration of the different environments, giving a constant evaluation of his didactic progress, whenever the student wishes to. In this phase, teacher-tutor, by means of interactive dialogues of the Socratic style, helps the student to analyze his own thinking and to discover and correct not only his mistakes, but also their causes.

3.2 "One-to-Many" Scenario (Collaborative Learning Mode)

In this scenario, by means of forums, wikis and synchronic meetings in the Virtual Classroom and on the UNINETTUNO Island of knowledge on second life, the teacher/tutor organizes and structures collaborative learning sessions, to promote interaction among the different actors of the educational process. The teacher-tutor actively directs the work of the groups in order to guide it.

The teacher-tutor has to:

- Organize group objectives clearly and precisely in order to prevent wasting their energies on insignificant interactions and activities;
- Define specialized tasks and assign them to the various members;
- Clearly define the personal responsibilities of each member.

Particular attention must be paid to the group objectives, which have various specific functions. The tasks will be selected so as to offer a stimulating but not impossible challenge in order to activate motivation and stimulate the sensation of self-effectiveness. In particular, the tasks must be complicated enough to:

- Allow each participant to make his contribution to the objective set;
- Ensure the participants realize that the group has greater skills and resources than the individual members.

Briefly, the teacher/tutor has to:

- Play the role of teacher-director that designs learning scenarios and who, later on, cooperates with his "students" to create and educational path that should take into account different styles of learning;
- Supply the students not only with theoretical and conceptual tools, but also tools that could allow them to transform knowledge into practical abilities, then into professional skills;
- Promote, thanks to the "virtual laboratories", the integration between knowing and being able to do;
- Develop models of sharing knowledge with the other users of the Web promoting collaborative learning processes;
- Play the role of somebody who orientates and

facilitates and give everybody the necessary tools to help the student find the information he needs on the Net and avoid his getting lost in the Web Hyperspace;

- Promote socialization models on the Net between distance students and teachers communities [6].

4. New Learning Models

In the open learning environments, the students can freely choose whether to pass from theoretical instruction to practical training, to surf on real time in large multimedia databases and implement bi-directional and interactive communication models, having them at the centre of the teaching and learning process. Open and flexible computer-based teaching environments allowed our model to integrate various languages, to implement a new communication line, to allow students to access the contents of dynamic and interactive knowledge and to make them actively participate in the learning process [7].

With regard to the development of learning, it is important to note that the study strategies set up during the use of the digitized video lessons allow setting up a learning process where it is the student who masters time. Actually, the student can watch and watch again parts of the videolessons as many time he wishes to according to his needs; he can pause to think and see if he needs to consult further sources, he can see again what he has already seen to enhance his long-term memory; he cans see other parts of the video that can have interesting connections with other material and other sources.

These are not only technical functions linked to the modes of use of the videolessons, but also meta-cognitive strategies that can facilitate self-evaluation of one's own comprehension activities. During a traditional lesson, it is not always easy to stop the professor to make him repeat what has explained, it is not practically possible to stop to reflect or consult other sources [8].

These new tools of knowledge memorization allow overcoming the limit of simultaneousness of the teaching-learning process that takes place in the traditional training process. This allows making the whole process more flexible and triggering new interactive learning processes. The student, besides having the possibility to customize all his study paths, can interact with different materials and realize a multimedia and hypertextual study strategy; he can organize the stored knowledge using different registers such as text, sound and pictures; he can interrupt viewing the videolessons to consult databases or texts available in the virtual library; he can try practical activities in the laboratory to see if he can transform his theoretical knowledge in practical abilities; he can navigate the Internet to enrich the subject with information that can come from different cultural and linguistic settings, or interact with other students and experts on the subject by means of forums and chats. More specifically, a complete hypertextual learning is realized [9].

Many authors having a cognitive and connectivity approach agree on defining the hypertextual technologies as a tool capable of favoring a new kind of learning. Since there is a substantial analogy between the network of links typical of a hypertext and that of the working of the human mind, meant as a neural network [10].

Hypertextual learning guides the student in his explorative dynamics by proposing to him a non-linear type of knowledge that is made up of plots and connections among nodes.

In this way a learning strategy, whose main features are the following, develops:

- An associative and non-linear form of organization of the information;
- The presence of diversified and alternative paths that can be freely selected and viewed;
- The presence of multimedia data: texts, pictures, audio, animations, videos, laboratory experience, discussions.

In addition, hypertextual learning promotes autonomy and makes the student become also author since it give him the possibility to realize navigation paths of his own among the nodes of knowledge proposed and to choose the level of detail and analysis he aims to reach.

Actually, the student is given a learning environment that stimulates exploration and discovery, a tool to "learn how to learn", to develop new learning strategies, to enhance cognitive processing.

The customization of the learning paths gives also the possibility of incremental access by the student at different levels of knowledge. In this sense, hypertextual learning can be considered as a flexible process since it respects the different learning styles and allow for a targeted use in function of pre-requisites and of students' past knowledge.

Thinking is above all creating interconnection among the elements of knowledge: therefore, the Internet-based platform of the International Telematic University UNINETTUNO stimulates a learning of network of concepts rather than scattered pieces of information ore sequences. In addition, the feeling of be a protagonist enhances the student's motivation and, consequently, reduces the cognitive effort.

5. Conclusions

The International Telematic University UNINETTUNO psycho-pedagogic model has rapidly become a global model, acknowledged at an international level thanks to several agreements concluded between UNINETTUNO and ministries, institutions and universities of other countries; thanks to this effort towards internationalization, today UNINETTUNO can count on students coming from 74 different countries of the world.

The international experience of the International Telematic University UNINETTUNO, and more specifically that made in the Mediterranean Area, proves that it is possible to share curricula and create, jointly with universities belonging to different political and cultural backgrounds, new educational models that take into account the changes brought about by globalization. A concrete example is the one that enabled the conclusion of an agreement aimed at a double title, jointly with Helwan University; after a first phase of analysis of the contents of the respective study programs for the degree course in computer engineering, at a general structuring level as well as at the level of the contents treated in the individual course, it appeared that, in spite of the different timing structure, the issues courses treated in the 3 years of UNINETTUNO degree course corresponded to the first four-year course delivered in Egypt. Based on the results gained from this preliminary analysis, we designed a common study program according to which the students get an Italian (and therefore European) study title that is further integrated by including the subjects that are envisaged by their fifth year of study—and that are not comprised in UNINETTUNO three-year study program—thus enabling them to get an Egyptian five-year study title. And this resulted into study program that is acknowledged in Egypt, in Italy and in Europe. Jointly, the interconnected intelligences of teachers and students of the Northern and Southern shores of the world, thanks to new models of interaction and new socialization and collaboration tools, typical of the Web 2.0, produce new educational contents and new knowledge; they develop a network of competences and expertise, not imposing cultural models to each others, but based on intercultural and inter-linguistic exchange and cooperation.

The new communication technologies can bring knowledge and expertise into the homes of all the citizens of world; with no more limits of space and time, all can follow courses to become literate, to acquire new skills as well as to enhance a system of shared values. When building and spreading knowledge on the Internet frontiers are uncertain, borders are places for continuity, not for conflicts.

Today the knowledge networks can bring about new wealth; they can offer anybody the teachings of the best scientists and scholars of the world in a free and democratic way. Distance universities can allow for interaction between professors and students of different universities and can really give a prompt appropriate answer to the needs for internationalization of the educational and training systems to prepare the competences required by the new global labor markets.

As consequence, today the distance university can meet the needs of the new market of knowledge: exhibit its quality label; grant the user; help transforming the university into an open system, capable of constantly updating itself and integrating all the knowledge available on the Web and implement the exchange of knowledge worldwide.

Only if we implement powerful policies aimed at democratizing the access to knowledge, will we be able to lay the foundations on which to make skilled men and women act and jointly create the values of solidarity and respect of differences, thanks to which the world will more easily share those universal values that, in principle, are accepted by everybody, of justice and peace.

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Computer Technology and Application 4 (2013) 485-488

Binary Cyclic Codes and Minimal Codewords

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Received: September 16, 2013 / Accepted: September 18, 2013 / Published: September 25, 2013.

Abstract: Cyclic codes form an important class of codes. They have very interesting algebraic structure. Furthermore, they are equivalent to many important codes, such as binary Hamming codes, Golay codes and BCH codes. Minimal codewords in linear codes are widely used in constructing decoding algorithms and studying linear secret sharing scheme. In this paper, we show that in the binary cyclic code all of the codewords are minimal, except 0 and 1. Then, we obtain a result about the number of minimal codewords in the binary cyclic codes.

Key words: Linear code, cyclic code, binary cyclic code, generator polynomial, minimal codeword, secret sharing.

1. Introduction

The subject of this correspondence is minimal codewords in the binary cyclic codes. Minimal codewords were studied in combinatorics [1]. In the coding theory, it used to construct secret sharing schemes. In principle, every linear code can be used to construct secret sharing schemes [2]. The minimal codewords in linear codes describe access structures in the secret sharing schemes [1].

A fundamental subclass of linear codes is given by cyclic codes. Binary cyclic codes were first studied by Prange in 1957 [3].

We begin with some basic definitions in coding theory. Then we summarize the cyclic codes and minimal codewords. In this paper, we investigate the minimal codewords in the binary cyclic codes. In this context, we prove a theorem associated with the minimal codewords in the binary cyclic codes. From this theorem, we obtain a result. We determine the number of minimal codewords in the binary cyclic codes by this result.

Finally, we consider an example. In this paper, the finite field $GF(q)$ will be denoted by the symbol F_q.

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2. Basic Definitions

2.1 Definition of Linear Code

A linear $[n, k, d]$ −code C over F_q is a subspace of $(F_q)^n$, where n is any positive integer, k is the dimension of C and d is the minimum distance of the code C [4].

2.2 Definition of Generator Matrix

A $k \times n$ generator matrix G obtained by writing the base vectors of the code C as rows of G is called a generator matrix of the linear $[n, k]$ −code C [4].

3 Cyclic Codes

Definition 1

A code C is cyclic if C is a linear code, any cyclic shift of a codeword is also a codeword, i.e. whenever $a_0 a_1 \dots a_{n-1} \in C$, then also $a_{n-1} a_0 a_1 \dots a_{n-2} \in C$ [4].

Example 1

The binary code $C = \{000, 101, 011, 110\}$ is cyclic [4].

Theorem 1

A code C in $F_q[x]/(x^n - 1)$ is a cyclic code if and only if C satisfies the following two conditions:

$$a(x), b(x) \in C \Leftrightarrow a(x) + b(x) \in C$$

$$a(x) \in C \text{ and }$$

$$r(x) \in F_q[x]/(x^n - 1) \Rightarrow r(x)a(x) \in C$$

where we denote by $F_q[x]/(x^n-1)$ the set of polynomials in $F_q[x]$ of degree less than $\deg(x^n\text{-}1)$ [4].

Theorem 2

For any $f(x) \in F_q[x]/(x^n-1)$, the set $< f(x) >$ is a cyclic code and it is called the code generated by $f(x)$ [4].

Theorem 3

Let C be a nonzero cyclic code in $F_q[x]/(x^n-1)$. Then, there exists a unique monic polynomial $g(x)$ of smallest degree in C; $C = < g(x) >$; $g(x)$ is a factor of x^n-1 [4].

Definition 2

Given by Theorem 3, in a nonzero cyclic code C the monic polynomial of least degree is called the generator polynomial of C [4].

Example 2

We will find all the binary cyclic codes of length 3.

$x^{\mathbf{3}}-1=(x+1).(x^2+x+1)$,

where, $(x+1)$ and (x^2+x+1) are irreducible over F_2. So, by Theorem 3, Table 1 is a complete list of binary cyclic codes of length 3 [4].

Theorem 4

Let $g(x) = g_0 + g_1(x) + \cdots + g_{n-k}x^{n-k}$ be the generator polynomial of a cyclic code. Then g_0 is a nonzero [4].

4. Minimal Codewords

Now, we will remember other definitions associated with subject.

4.1 Definition of Support of a Vector

The set $S = \{0 \le i \le n-1 |\, c_i \ne 0\}$ is called support of a vector $c = c_1c_2 \ldots c_n \in (F_q)^n$. a codeword c_2 covers a codeword c_1 if the support of c_2 contains that of c_1 [7].

4.2 Definition of Minimal Codeword

A minimal codeword c is a codeword which covers just only its scalar multiples [7].

5. Binary Cyclic Codes and Minimal Codewords

In this section, we investigate the minimal codewords in the binary cyclic codes. It is important that determining the minimal codewords for any linear code. For example, we know that every linear code can be used to construct secret sharing schemes [2].

It is known that the minimal codewords determining the access structure of the secret sharing scheme. So, it is important that determining the minimal codewords in the secret sharing schemes based on the binary cyclic codes.

In the following theorem, we will give a result about minimality of the codewords in the binary cyclic codes.

Theorem 5

Let C be a cyclic $[n,k]-$code over F_2 with generator polynomial $g(x) = g_0 + g_1(x) + \cdots + g_{n-k}x^{n-k}$ of degree $n-k$. All of the codewords in the binary cyclic $[n,k]-$ code C generated by $g(x)$ are minimal, except 0 and 1.

We know that a $[n,k]-$linear code C is called a cyclic code if every cyclic shift of a codeword in C is also a codeword in C [4]. So, the position of $1s$ in each of codeword in C is different. Thus, the supports of all of the codewords in C do not cover each other, except 0 and 1. Therefore, we can say that all of the codewords in the binary cyclic code C are minimal, except 0 and 1.

From Theorem 5, we obtain the following result.

Corollary: Let C be a $[n,k]-$cyclic code over F_2 with generator polynomial $g(x) = g_0 + g_1(x) + \cdots + g_{n-k}x^{n-k}$ of degree $n-k$. In the binary cyclic $[n,k]-$ code C generated by $g(x)$, there are altogether 2^k-2 minimal codewords.

We know that $|C| = 2^k$ and by Theorem 5, all of the codewords in the binary cyclic $[n,k]-$code C generated by $g(x)$ are minimal, except 0 and 1.

Therefore, we obtain that there are altogether 2^k-2 minimal codewords in the binary cyclic code C.

Table 1 A complete list of binary cyclic codes of length 3.

Generator polynomial	Code in $F_2[x]/(x^3-1)$	Corresponding code in $(F_2)^3$
1	all of $F_2[x]/(x^3-1)$	all of $(F_2)^3$
$x+1$	$\{0, 1+x, x+x^2, 1+x^2\}$	$\{000, 110, 011, 101\}$
x^2+x+1	$\{0, 1+x+x^2\}$	$\{000, 111\}$
$x^3-1=0$	$\{0\}$	$\{000\}$

Table 2 The [5, 7] binary cyclic code C is generated by $g(x)=1+x+x^3$.

Messages	Codewords	Code polynomials
(0000)	0000000	$0=0.g(x)$
(1000)	1101000	$1+x+x^3=1.g(x)$
(0100)	0110100	$x+x^2+x^4=x.g(x)$
(1100)	1011100	$1+x^2+x^3+x^4=(1+x).g(x)$
(0010)	0011010	$x^2+x^3+x^5=x^2.g(x)$
(1010)	1110010	$1+x+x^2+x^5=(1+x^2).g(x)$
(0110)	0101110	$x+x^3+x^4+x^5=(x+x^2).g(x)$
(1110)	1000110	$1+x^4+x^5=(1+x+x^2).g(x)$
(0001)	0001101	$x^3+x^4+x^6=x^3.g(x)$
(1001)	1100101	$1+x+x^4+x^6=(1+x^3).g(x)$
(0101)	0111001	$x+x^2+x^3+x^6=(x+x^3).g(x)$
(1101)	1010001	$1+x^2+x^6=(1+x+x^3).g(x)$
(0011)	0010111	$x^2+x^4+x^5+x^6=(x^2+x^3).g(x)$
(1011)	1111111	$1+x+x^2+x^3+x^4+x^5+x^6=(1+x^2+x^3).g(x)$
(0111)	0100011	$x+x^5+x^6=(x+x^2+x^3).g(x)$
(1111)	1001011	$1+x^3+x^5+x^6=(1+x+x^2+x^3).g(x)$

Example 3

A binary cyclic $[7,4]-$code C is generated by $g(x)=1+x+x^3$ given by Table 2.

Now, we will find the supports of the codewords in Table 2, except 0 and 1:

$\{1,2,4\},\{2,3,5\},\{1,3,4,5\},\{3,4,6\},\{1,2,3,6\},$ $\{2,4,5,6\},\{1,5,6\},\{4,5,7\},\{1,2,5,7\},\{2,3,4,7\},$ $\{1,3,7\},\{3,5,6,7\},\{2,6,7\},\{1,4,6,7\}.$

If we examine the set of supports, we can see that these sets do not cover each other, except 0 and 1, which is all of the codewords in Table 2 are minimal, except 0 and 1.

So, the number of minimal codewords in the binary cyclic code C is 14:

$2^k-2=2^4-2=16-2=14.$

6. Conclusions

In this paper, the author investigated the minimal codewords in the binary cyclic codes and obtained following results:

Let C be a $[n,k]-$cyclic code over F_2 with generator polynomial.

$g(x)=g_0+g_1(x)+\cdots+g_{n-k}x^{n-k}$ of degree $n-k$. All of the codewords in the $[n,k]-$binary cyclic code C generated by $g(x)$ are minimal, except 0 and 1.

Let C be an $[n,k]-$cyclic code over F_2 with generator polynomial $g(x)=g_0+g_1(x)+\cdots+g_{n-k}x^{n-k}$ of degree $n-k$. In the $[n,k]-$binary cyclic code C generated by $g(x)$, there are altogether 2^k-2 minimal codewords.

In conclusion, this results can use for the secret sharing schemes based on the binary cyclic codes.

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Computer Technology and Application 4 (2013) 489-492

Enterprise Content Management with Information Architecture: Guidelines to Structure the Information Assets

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Received: September 3, 2013 / Accepted: September 18, 2013 / Published: September 25, 2013.

Abstract: CM (content management) is a strategic discipline that should support the information assets of a company. Although there are some technological instruments structuring this work, the methods that have been used must have improvement to a better use. In this sense, IA (information architecture), as a process that helps users to manage and find information, can collaborate with the organization of this assets allowing the best identification and categorization of information, as well as providing improvements in the website navigation in Intranets and Internet. This article introduces part of a research that deals with the use of IA for developing and structuring the project of Dataprev about the content management for Brazilian social security system.

Key words: CM, IA, Dataprev, Brazilian social security, Brazil.

1. Introduction

The challenge in information and data management is increasing, as the speed in which constantly grows and varies is extremely high. The scenery we have today is one of information and document boom—the Age of Knowledge Explosion [1] and it is impossible to go through this issue without approaching the elements which sustain the processes of work in the organizations [2].

The information explosion has brought up extremely intense implications on the processes of management of the information assets of an organization [3]. The use of CM is an approach whose aim is to reduce these implications and which has been used in organizations [4]. Casting an interdisciplinary look at the CM issue, it is possible to find one of today's deeply explored grounds in computing: the use of technological instruments to administer information and documents by means of CMS (content management systems) and Web Portal [5].

The Brazilian social security system generates a great volume of data, with a variety of types originated from many different sources. In the present day, there is a monthly payment of approximately 24 million of benefits, with distinct benefit categories, each with distinct characteristics, demanding a differentiated treatment. This information is stored in very large databases and must be available to Brazilian citizens. In the universe of non-structured documents and information, studies point to a process volume of around 32,000 document movements per day, including administration processes, benefit processes and other tasks [5]. This article introduces part of a research that deals with the use of IA for development and structuring the project of Dataprev about CM for Brazilian social security system.

Finally, the acknowledgement of competence and value existing in enterprises and institutions depends directly on the efficiency of their IM (information

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management). The building of a framework for the structuring of the information inside an organization is vital to obtain success in its management.

In this paper, we introduce part of research that deals with the use of IA for developing and structuring the project of Dataprev about the CM for Brazilian social security system. The paper is organized as follows: Section 2 discusses the use of IA to structure content assets with content, context and users; Section 3 introduces the actions it have guided the project execution; Section 4 presents final considerations.

2. The Use of IA to Structure Content Assets

Content assets are fundamental to the production of knowledge for today's society. The activities of meeting, selection, encoding, reduction, classifying and storing lead to stock organization and control for immediate or future use, always with the intention to help in the process of knowledge production. Information stocks are eminent parts in the composition of the value of content assets. On the other hand, Information stocks are static; they themselves do not produce any knowledge. This only happens when the process of communication between senders and receivers—going through the information stocks starts. Information needs to be transmitted and accepted as it is [6].

With a growing use of solutions that make use of Intranets and Extranets for sharing and dissemination of information, it is observed that there is still a lot of effort in managing web environments of organizations. In this way, the use of CMS tools and Web Portals has emerged as technological solution to solving problems originating in IM.

Some relevant questions need to be answered in order to view the building of a process of CM in an adequate way, structure its discussion and lead its development, as it is necessary to know, among other things:

- How is information flow?
- What information and classification process—taxonomy—is used by the users community?
- The whole information produced, institutional or not, allows easily that user stores and recover itself?
- How has been using structured information?
- How has been using non structured information?
- How has been using digital assets (films, videos, sounds, etc.)?

At the beginning of the 90s, Benjamin and Blunt [7] made a re-reading of the main predictions that they had made for the previous decade, and also new predictions for the next one. For a foreseeable future they pointed tendencies to: technologies, architecture and patterns, services, investments and economic aspects, besides processes for appliance development and change management. Among several of the appointed challenges, the most important one would be the description and integration of business processes and technological matters, which would be represented by an IA. This architecture, besides justifying investments in IT, would be a bridge connecting strategic guidance to the new technologies.

In this sense it is necessary to use a trans-multi-disciplinary approach [8], thus the structuring of this important theme embraces several disciplines and gather different approaches, so much social as technological, that will be able to be materialized in an IA, among them [5].

2.1 Content and Context

- Business process management systems, business processes re-engineering and workflow;
- The systems, chaos theory and complexity, the organizational behavior , change and learning;
- The knowledge management, artificial intelligence and knowledge-based systems;
- Information and computer science, software engineering, librarianship;
- Information retrieval and domain analysis.

2.2 Users

- Communication and cognition, linguistics, psychology, sociology and anthropology;

- Visual and graphic design, besides human-computer interface design.

One of the first steps towards establishing an adequate treatment of interfaces and content management is the assumption that those information objects deal with entrepreneurial assets. In other words, going from information to knowledge in the productive chain, these are the necessary materials to transform structures and to produce knowledge for humankind. In this direction, the IA assists all employees and institutions, so it should be observed like a help tool. As a matter of fact, the architecture design should be responsibility of all, once it is applicable for every type of information.

In the Web environment, it is possible to realize that the discipline is an extremely fertile and emerging ground supported by practice communities, with focus in developing the principles for the project and to organize digital information assets. This structuring can be obtained with definition of key identifiers and navigation outlines to help the design of information and systems services. Besides that, IA needs to treat the structural information systems design, to facilitate its tasks execution and the intuitive access. Finally, it is possible to synthesize its definition like: the art and science of classifying sites web and intranets to aid people to find and manage information [9].

3. Actions Developed

To develop the project, the next guidelines are being followed:

- Involve stakeholders and understand the environment, enterprise business process, goals and political context of the company, as well as to observe previous experiences;
- Integrate teams making the definitions homogeneous and consequently also homogenously IA construction itself;
- If there are opinion differences deals with information reconciliation;
- Develop the work breaking the subject complexity, dividing wide subjects into smaller sections;
- Identify the information assets (data, documents, images, audio, video, applications, emails, etc);
- Shape assets defining how it is used, its value and purpose;
- Build a Metadata Management policy, identify metadata and retrieval forms;
- Develop templates and standards to improve the data use;
- Establish a asset classification standard for each asset that has been identified;
- Improve the project team introducing new professional skills to treat the information assets;
- Explore the possibility to develop a taxonomy to work these concepts and the existing synonyms, besides controlled vocabulary, field domain, hierarchy;
- Create a conceptual map to exhibit graphically these categories, as well as the existing relationship among the categories;
- Identify roles and responsibilities and evaluate web sites constantly;
- Announce constantly the work that is being elaborated;
- Do constant technological revaluation of the tools used; make benchmarking and observe market evolution and trends.

4. Final Considerations

As presented at this report introduction, the rising of the Web environment has contributed to increase the amount of problems of IM, which caused a shift of focus from the resolution of the problem to the use of technological approaches. Mostly on large information volume environment, the retrieval solutions began to be structured from magical search mechanisms that proposed to bring all the relevant information. As from the implementation of this project and with the support of the theoretical contribution presented here, we hope to reduce the uncertainties of the IM, contributing to the process of content management in the Web environment, especially to the set of information of the Brazilian social security system.

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Computer Technology and Application 4 (2013) 493-503

Why Higher Education's Pursuit of eLearning Technology Fails Minority Learners

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Received: September 4, 2013 / Accepted: September 12, 2013 / Published: September 25, 2013.

Abstract: As technology becomes increasingly integrated into the teaching and learning processes at the university level, it is imperative that research be conducted in relation to the impact of technology acquisition on minority learning populations. Research suggests that we need to improve the ways technology is applied, adopted and introduced and that higher levels of support should be provided to minority and nontraditional learning populations as they immerse themselves into higher education environments. Avenues for discussion of cost-effective technology integration and transition are explored; data identifies a need for more effective selection and alignment of learning needs with learning tools earlier on in the process of technology implementation across campuses. Research suggests this supports student presence, persistence, retention and success. Without it, however, we fail to support the very learners we seek to provide higher levels of access and opportunity. This failure will impact learners and institutions alike by placing disadvantage populations in precarious positions and universities having to choose between cultural, economic and human capital. The paper is organized as follows: Section 1: Introduction; Section 2: Need for Understanding Minority Enrollment Patterns; Section 3: Analysis of Report Data; Section 4: Strategy; Section 5: Conclusions.

Key words: Technology, learning, research, minorities, support.

1. Introduction

Nontraditional learners in American higher education have historically represented the antithesis of the status quo. This learning population has been forced to navigate an institutionalized dogma that is both suffocating, difficult and it is one that has persisted over time. In the interest of the discussion, a more concrete definition of nontraditional groups must be provided. The term "nontraditional" can often be misleading, as discussed by Ogren [1]. It implies that these atypical students are new to higher education, and colleges and universities traditionally have not served people like them. Research indicates that generations of nontraditional students have attended virtually every type of higher education institution [2-3], so for the essay, we should not confuse the term with the historical presence of this learning population. In fact, documentation shows that the change in America from elite to a mass higher education system in the late 20th century resulted in a significant increase in the number of students historically considered nontraditional, making them a majority in higher education today [4].

Characteristics of nontraditional learners in higher education are described to commonly encompass race, socio-economic status, gender, ethnicity, age, attendance frequency and physical residence in relation to campus [5-8]; first generation students are also commonly included in this discussion [9]. This type of learning often takes place within myriad contexts, which are commonly traditional in scope. These contexts include distance, independent, correspondence, self-directed or open learning. In

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comparison, the traditional learner is often straight out of secondary educational institutions, aged 18 to 20, and living within proximity of campus locations they attend, retain a full-time student status, are typically from socially dominant groups, are able to access adequate financial aid and are generally understood within a campus community [10]. This paper will define the nontraditional student as an atypical learner characterized by a single or several differentiating aspects from that of a traditional learner such as race, socio-economic status, gender, ethnicity, age, attendance frequency, first generation attendance or physical residence in relation to campus.

Diversity, minority, and nontraditional student enrollment and eLearning are increasingly becoming synonymous with future growth and projected outlook in higher education. Between 2009 and 2020, in the NCES (national center for education statistics) projects, there will be a 21% increase in students aged 25 to 34 and a 16% increase in students aged 35 and above [11]. Research also suggests minority populations will most likely account for a majority of the American populace within the next twenty years [12]. As institutions of higher education in the U.S. continue to push for higher enrollments, the importance of diversity, minorities, and eLearning on campuses has become a focal point for institutional growth models.

Research generally suggests that campus environments and policies that foster interaction among diverse students create situations that are not only enlightening, but effective for most student populations. White and minority students alike, typically enter college without experience with diverse peer groups. Colleges that diversify their student bodies and institute policies that foster genuine interaction across race and ethnicity provide the first opportunity for many students to learn from peers with different cultures, values and experiences [13]. Diversity is found to be "especially influential in accounting for higher levels of intellectual engagement and self-assessed academic skills for groups of students" [13].

Distance education has embraced diversity and used it as a catalyst for increasing access and enrollment within higher education over the past decade. In 2007-2008, about 4.3 million undergraduate students, or 20% of all undergraduates, took at least one distance education course. About 0.8 million, or 4% of all undergraduates, took their entire program through distance education. The percentage of undergraduates who took any distance education courses rose from 16% in 2003-2004 to 20% in 2007-2008. The percentage of post baccalaureate students who took their entire program through distance education (9%) was higher than the percentage at the undergraduate level [14].

Minority populations have been as much of a change agent on campuses as any other variable. Patterns suggest, however, that when discussing the use of technology in educational contexts that these populations can struggle to adjust and the percentage of persistence begins to decrease. Rovai points out that persistence is often viewed as a measure of how well students integrate into a particular school [15] or learning environment. Tinto's model on student integration identifies correlations between student integration and the academic and social experiences they have [16]. Success of this model was measured by GPA (grade point averages) and the level of interaction and involvement students had with peers, instructors and extracurricular activity. An evaluation of the model further suggests that higher levels of student commitment mostly resulted in higher levels of persistence.

When discussing the technology use of students and levels of persistence, research on student populations suggests that a proportion of students who are not skilled users of technology feel disadvantaged in the learning process [17]. There also remains a digital divide based on race/Hispanic origin, income, location (central city and rural areas), and other demographic characteristics. The "lower socioeconomic and minority groups continue to fall further behind the more affluent population” [18]. This not only encompasses access to technology, but also any issue related to how technology is then used as part of someone’s learning processes. Studies also suggest that students are more likely to show similarities in Internet use in line with their economic rather than with their cultural background, and have identified patterns evidencing that students from richer areas are much more likely to use the Internet for academic purposes than those teenagers in poorer regions. Implications are strongly tied to the design and integration of technology for the learning process. In designing courses using a blended pedagogical approach, we really need to take into account that some students will be far less used the Internet for finding information and for problem solving [19]. Rovai posits that virtual learning environments and tools differ from those typically seen and used in traditional on-campus settings [15]. Additionally, several authors also stress the importance of understanding the needs and skills of both online and distance education students [20-22], most of whom are considered nontraditional learners.

Research indicates that institutions should consider assessing the technical literacy of their students upon entry and offer opportunities for technical training or on-demand skills building. These assessments can be directly tied to the increased use of technology in the learning process, but little research has been conducted to further understand the potential students have for learning with it [17]. In addition to Tinto’s model of students, persistence training is shown to be more important to students than more or “better” technology and is essential for their success in a world where these skills are expected [16]. Most students agree that basic technologies have the greatest impact on success. At least 1/3 of all students are inadequately prepared to use technology needed in their courses [23].

Longitudinal research suggests that technology in higher education should be less about innovation and more about better use of existing technologies [23]. Academic success is still underpinned by face-to-face interactions [23], because the relative recentness of e-Learning technology as a tool in higher education instruction using technology often fails to be responsive to the diverse backgrounds of students [24].

Impacts of e-Learning technology integration on college completion rates impacted minority populations differently than their white counterparts. Completion rates for first-time, full-time students who sought a bachelor’s degree vary by race and ethnicity. Asian/Pacific Islander students had the highest graduation and completion rate (69%), followed by white students (62%), Hispanic students (50%) and black and American Indian/Alaska native students (39% each) [25]. The implications of this level of research are quite important when discussing a universities bottom line, and how addressing this might conversely impact the percentage of students who chose to drop out of their schooling for reasons connected to technology and the digital divide. In addition, research needs to explore avenues related to persistence in distance education programs and those traditional programs that use a high percentage of eLearning technology. Carr noted that persistence in distance education programs is often 10%-20% points lower than in traditional programs. She also reported significant variation among institutions; with some postsecondary schools reporting course-completion rates of more than 80% and others finding that fewer than 50% of distance education students finish their courses [26]. Moreover, Rovai finds that “persistence is an issue of increasing importance for both traditional and distance education programs in view of the increasing enrollments of nontraditional students in both programs” [15].

2. Need for Understanding Enrollment Patterns in Minority Populations

The percentage of American college students who are Hispanic, Asian/Pacific Islander, and Black has been increasing. From 1976 to 2010, the percentage of

Hispanic students rose from 3% to 13%, the percentage of Asian/Pacific Islander students rose from 2% to 6%, and the percentage of Black students rose from 9% to 14% [25]. During the same period, the percentage of White students fell from 83% to 61%. Race/ethnicity is not reported for nonresident aliens, who made up 2% and 3% of total enrollment in 1976 and 2010, respectively [27]. Reviewing these statistics, it is clear that the growth model for higher education is becoming more heavily reliant on the enrollment of minority populations, and that successful graduation rates are imperative to the stability of the model. This notion is also supported by the current retention initiatives being pushed forward by the US Department of Education.

Nontraditional learning populations in American higher education have increasingly become a greater and more influential part of the greater framework of education. Historically, however, the American system has failed to be influenced by some of the great minds of our countries minority populations. History, as Sumner outlines, has been largely in favor of serving the system; only strengthening the power it holds over those hoping to enroll or gain access to institutions of higher education and in more recent history; this might include access from a distance [28]. The highest achieving students from high income families are nearly four-times as likely as low-income students with the same academic accomplishments to end up in a highly selective university. In contemporary society, there is a disregard of higher education's contribution to economic inequality in the U.S., and despite higher levels of diversity on campuses, the growth of a historically outdated institutional state of mind that is resistant to change and diversity has not diminished over time but only become more influential. Schuetze and Slowey exhibit this in an article related to participation and exclusion [4]:

"The dramatic growth in student numbers associated with the shift from elite to mass systems across virtually all developed countries is central to current transformations in terms of structure, purpose, social and economic role of higher education. As a part of this process of expansion and heterogenization, new groups of students who, for a complex range of social, economic and cultural reasons were traditionally excluded from or under-represented in higher education, might be expected to participate in increasing numbers".

To suggest that over time American higher education has become increasingly diverse is not by any means misleading. In reality, this masks the burden that a large portion of learners feels to make an impact as they continue to be measured by the growth in numbers and not the impact they have intellectually in society; looking specifically at employment rates of minority populations post-degree shows that discrimination in hiring practice still exists and thus this undermines the advantage individuals whom obtain degrees might be afforded. Beyond that, the interest in the economics of education has continued to grow in the last few decades, placing further emphasis on continual growth to support an institution's bottom line and also to focus on the value of degrees. In 1999-2000, 73% of all undergraduates had one or more nontraditional characteristics [29]. The nontraditional population is also expected to increase in the coming years. Between 2009 and 2020, in NCES projects, there will be a 21% increase in students aged 25 to 34 and a 16% increase in students aged 35 and above [11]. Research also suggests minority populations will most likely account for a majority of the American populace within the next twenty years [12].

There is pressure building for minority populations to make a greater impact on the American landscape; equal education does not mean equal chance. "Americans endorse equality of opportunity, yet we also embrace living in a competitive meritocracy where the most gifted and hard working in particular areas get richly rewarded" [30]. When reflecting on the historical tendency of higher education to be self-serving, there is a clear connection then between higher levels of access we see now and the need for those who have been traditionally left out to make a meaningful impact through these newly opened avenues. Impact in this case must go beyond that of emotional connections of minorities toward the general inclusive nature of society, but move more aptly towards a vision that includes themselves in the advancement efforts of society itself. Underrepresented groups need to strive for impacts beyond just investing in and graduating from higher education. Focus should navigate towards concepts tied to social welfare, a just society, economic and social equality, as well as identifying more pathways to success. Historically, American higher education systems have done little to support what has always been a rapidly changing landscape. As a consequence, the evolution of elitism has occurred; the ability of institutions dissolves engaging the multicultural society in discussion surrounding the values and mission that hold up the system [12].

Through the liberal lens, one can deduce that nontraditional learning populations have often been pushed towards career or vocational oriented opportunities over time. Evidence suggests that this has more to do with factors tied to the inability to navigate systems of higher education, political pressure to obtain at least one year of higher education, lack of knowledge related to national service programs and nonprofits that support continued education, and a complete lack of equity [30]; the aforementioned factors have undermined the potential these populations ultimately have, at times breaking confidence in the potential that programs suggest they offer. The development of more practical and utilitarian programs has been a direct contrast to what liberal theory suggests. The ability to associate the value of education to life experiences has been taken from many nontraditional learners by simply suggesting they should not be part of continuing education and lifelong learning. The historical relationship between adult education, power and social control has limited the ability of nontraditional learning populations to use freedom as a tool for success by continuing to serve the system, which in turn has limited access to such aspects of society. As education continues to become more of a commodity that is used to access the different levels of society you can see how the fabric of liberal education is tainted and the powers that be continue to remain in control.

Mezirow describes other major implications for learning trends related to the commoditization of learning and the impact on the learner themselves [31]. Specifically, Mezirow suggests the impact is forcing learners to become more apathetic and "impervious to the efforts of their professors to expose them to new ideas and new information" [31]. This has profound impacts when it comes to nontraditional learners and their quest for acceptance into higher education, to grow knowledge and to access and acquire skills. In the American society, education has historically been established by the social elite as a gateway to economic prosperity, but progress for nontraditional learners is often thwarted as they strive to make progress similar to their peers of higher socio-economic status [32-33]. The need for the American populous to access higher learning is further pressed by economic and social pressures being submitted by government, and the general population in relation to employability [33]. Yorke and Knight explain that a key to societal acceptability of the institution of higher education and of those who enter into it has been the alignment of employability with higher learning [34]. The more that education becomes a commodity, the more society will need to access it to be considered successful. With the continued alignment of employability with educational attainment, it becomes even more necessary for nontraditional learning populations to gain acceptance or risk being further removed from the shrinking list of opportunities within our own society and the class structures that currently exist. Contemporary society requires that individuals possess basic knowledge of the world around them, and it suggests the more education we obtain the higher human capital we then acquire. This drives the contemporary education system to rank "private above public, research universities above teaching college, bachelor's above associate's degree, and liberal arts above vocational and technical education" [30]. Without access and acceptance to higher education communities and networks, there is a potential for fewer opportunities for the nontraditional student to acquire knowledge and leverage it for the betterment of society.

3. Analysis of Report Data

As part of the analysis, institutional reporting data were reviewed specifically identifying technology acquisitions and implementations at universities for learning purposes. Then the data were compared to the retention and graduation rates of minority student populations over that same time period. Students were broken into two categories: first year college students and those enrolled in college more than two years. The preliminary analyses show correlations between technology acquisition and rates of retention. For example, amongst the Black and Latino populations the retention of first year students seemingly decreases as the acquisition and implementation of technology increases, whereas within the same populations the longer the students are enrolled the more retention rates begin to level out. Geroski supports this notion by explaining that the usage of new technologies over time typically follows an S-curve, which builds on the premise that what limits the speed of usage is the lack of information available about the new technology, how to use it and what it does [35]. Other initial analysis of the data suggests that the higher frequency of technology acquisition the more likely it is for campuses to struggle with keeping minority student populations growing. The analysis is still in the preliminary states, but it seemingly can help explain the potential effects of continual adaptation of new eLearning technology on minority student populations, and can hopefully lead to further assessment of whether there are direct connections between institutional investment in eLearning technology and minority student retention and graduation rates over time.

4. Strategy

By nature, adult learners rely on their own experiences to guide them through learning processes. Merriam and Caffarella [36] support this, exemplifying how "numerous adult educators have underscored the fundamental role that experience plays in learning in adulthood" [31, 37-41]. Lindeman points out that adult experiences lead to their "living textbook", or catalog of experience, that is simply waiting to be employed once they identify it as important [40]. Mezirow further explores this through Habermas's ideas relating to the domains of adult learning [31]. He suggests that adults are likely to transform through reification and reflectivity of past experience. There are some scholars [42] believe that experiences are what create the most "genuine education" as it requires one to "connect what they have learned from current experiences to those in the past as well as see possible future implications" [36]. As one begins to consider the place of humans in the overall picture or landscape of history, it is not hard to see how learning from experience has allowed the development and evolution of thought and the growth of mankind to persist for a long period of time both physically and intellectually.

In order for this to occur, there must also have to be some level of freedom for people to think, undetermined by the world and society around them. Usher, Bryant and Johnston support this notion by describing experiences as being most similar to a textbook that can be "interpreted, possibly with great effort, and certainly with no final, definitive meaning" [41]. They suggest that learning and experience are closely connected and at any given time and place where each one has the ability to influence the learning process equally. One could argue that the world and context in which an individual exists is the determinant in decision-making practice within adults, but from the standpoint of the humanistic philosophy, this is simply not the case and the environment is instead viewed as a tool in the decision-making process. The meaning of adult education, as described by Lindeman, is to put meaning into the whole of life [40]. Jarvis posits that "social structures do not exist" and that people ritualize behavior, create patterns and as a result often take for granted or overlook the ritual that is involved [43]. He adds that "people know that they are free to act…but feel constrained to conform, often by relationships that are of their own making" [43], a conception of the over-socialized individual. He also suggests that freedom of learning can exist, and that "different forms of learning are possible in different situations…can occur wherever free will is exercised" and that "free will is valid" in learning and decision-making processes.

This is not to expressly say, however, that we as individual people are not at all influenced by the society or constructs that surround us. Studies show that decisions to be involved in the learning process are at times dictated by internal motivations that are influenced by the societal context [43-46]. Zeleny suggests that decision making is a three stages process that involves "a dynamic and interrelated unity of pre-decision, decision and post-decision stages" [46]. Beer supports this claim by explaining the process of making a decision in the following way [44].

The real decision under process involves a lot of people, and the whole structure is redolent with feedback. At every decisive moment, of which there will be great many within the total decision, we range ahead and back and sideways. We gauge effect of this sub-decision on everything we have tentatively decided already, and on the sub-decision left to take.

When you view the decision-making process in the way it is described above, you see that we as learners have the cognitive ability to break down cause and effect of decisions as they are being made in real-time environments and situations. Again, this is not to say that the decisions are not informed by the context in which we operate but that we are freely making decisions based on the understandings we have gained through experiences we have as learners. This can only occur if we have the freedom and the motivation to be involved in making decisions, which in fact we do.

The premise of humanist philosophy is to fully develop persons "who are open to change and continued learning…who strive for self-actualization and persons who can live together as fully functioning individuals" [47]. When considering the purpose of adult education, it is important to remember that adults involved with the learning process are driven to learn, and are actively engaged in using their learning to influence the growth and development of society. Adults are "unique individuals" with "emotions, attitudes, physical aspects" and personalities that are all important dimensions of their own humanness and intellectual development [47]. History has shown that both "institutions and individuals used education to further reformative and evolutionary change, and in other situations, they used education to maintain existing social, economic, and racial relationships" [48]. These traits and historical developments are what define the purpose of adult education in our society today.

Several scholars view the purpose of education as "a means for fostering self-actualization and fully-functioning individuals" [47], where situations allow "individual freedom, responsibility and natural goodness" to inform a student's ability to accurately identify their own needs as learners. In these situations the learner is often the driver or the center of learning processes with the teacher serving as more the facilitator, and experiences of the learner are used to garner further understanding and bring greater meaning to individuals. The learner-centered approach is a very important aspect to both the humanistic philosophy and that of the adult learner. In contemporary society, the evolution of thought and practice has been expedited and often "the urgency of dealing with social realities lies with adults" [36].

Initial analyses are suggesting that technology acquisition can create challenging and less manageable situations for minority learners. Efforts to explore how people learn with technology and the effect that personal and social factors have on the learning process have led to a few meaningful models that can be used to support this issue as it unfolds. Rovai identifies three variables that should be considered in developing strategies to address impacts of technology on retention rates of minorities: (1) student characteristics; (2) student skills prior to admission, during schooling, and in learning situations where new technology is applied; (3) understanding internal and external factors effecting students' learning [15]. These three items will help point support services more directly to challenges, more effectively identify students at risk, make effective recommendations for technology acquisition policy and procedures, further the understanding of minority populations and the learning preferences amongst individuals, and they can help support a higher level of presence and persistence in student populations that face adversity and struggles related to proper identification of self-discipline coping skills of minority learners. As time moves forward the makeup of higher education continues to become more diverse and less traditional, creating pressure on the institution to support myriad learning needs and expectations. In response, institutions are going to need to freely and smartly adopt new learning technology, while also developing broader applications of those technologies as a means to support the teaching and learning processes of a more diverse learner population. This strategy is currently used to attract more students to campuses in support of the fiscal pressures for continual growth, but it in turn has created more challenges for minority populations. Historically, studies have uncovered that technology adoption models have been aimed to engage and support faculty as they adopt tools into their own teaching practice, which has not been supportive of the needs displayed by most learning populations. Minority populations factor as an ever increasingly important piece of higher educations' growth model, but they are now facing challenges and have to overcome more obstacles than their counterparts when being asked to continually adopt new learning technology. Generally, this situation starts to dissolve the underpinnings of growth and learning models for institutions of higher education as minority students struggle to stay enrolled and graduate. This study presents learning opportunities and has applicability for institutions across the private for-profit, public, and private non-profit sectors.

5. Conclusions

As technology becomes increasingly integrated into the teaching and learning processes at the university level, it is imperative that research be conducted in relation to the impact of technology acquisition on minority learning populations. This study aimed at opening new avenues for discourse related to ways in which educators and administrators can design learning to incorporate technology in a more meaningful way, and to create environments that are more supportive of a diverse group of learners. Research suggests that we need to improve the ways technology is applied, adopted and introduced and that higher levels of support should be provided to minority and nontraditional learning populations as they immerse themselves into higher education environments. There are also potential avenues for discussion of cost-effective technology integration and transition to be explored. These data could help support more effective selection practices and align the learning needs with the learning tools earlier on in the process of technology implementation across campuses. Generally, the impact of such practice should be directly portrayed with increases in enrollments, higher retention of students, higher graduation rates, cost-effective administrations, and a more technology literate student body. As described, adult learning does not occur in a vacuum and there is evidence clearly showing that the learning process is informed by the amount of change and movement that occurs within society. Contemporary society relies on individuals to have a thorough understanding of things such as economics, diversity, and self-concept. When you view the demands of society and compare that to what is emphasized in adult education parallels clearly exist. The relationship between historical societal change over time and the mirroring of that change in the way adults are educated is easily depicted as something that cannot be debated. As stated earlier, "the urgency of dealing with social realities lies with adults". Social reality is not static. It constantly ebbs and flows to an inconsistent beat; one that is ever increasingly defined by a global context and an influx of variables such as technology.

Considering the current that society subscribes to is the one that moves rapidly, it can be inferred that "what one needs or wants to learn, what opportunities are available, the manner in which one learns—all are to a large extent determined by the society in which one lives" [36]. This society values aspects, in particular, those related to economics and technology. Often, these are closely tied together and work to shape the landscape in which we operate and compete in. Drucker provides a clear example in which technology, science and the growth of society are closely tied in the modern world [49]. He argues that the convergence of values on these variables has had a dramatic influence on the political and economic structure of our society and that the "explosive change" that has occurred in society over the last two hundred years can be directly related to the "immediate impact" technology has had on science; changing science from "being natural philosophy" into more of a "social institution" [49]. Economics and technology are just a few of the items that are strongly embedded in our societal value systems. The role adult education serves, as the construct being used to address and make meaning of societal change, is increasingly one that is more responsible for challenging adults to actively reflect and respond to the context that surrounds them through the employment of informed decisions.

When discussing content currently being addressed in adult education programs, the variables above need to be taken into consideration in order to ensure the curriculum in place is addressing the contemporary needs of the society in which we operate. It is highly important then to build a curriculum and programs that reflect the prior knowledge and experiences of learners, and that also place high emphasis on "recognizing the many places and ways they have gone about learning in adulthood" [36]. This not only provides a foundation for individuals to more effectively understand how they learn, but to empower them to integrate their experiences into the learning and decision-making processes they will go through as an adult learner both inside of and outside of the institution of higher education. The process is otherwise understood as a self-directed learning process, and this is an element that is supported within the humanist framework.

The self-directed learner is one that takes "the primary initiative for planning, carrying out, and evaluating their own learning experiences" [36]. Several authors have made clear connections between the humanist model and that of the self-directed learner [50-54]. Specifically, Brockett and Hiemstra used in concepts of personal responsibility in defining the differences between self-directed learning and the self-directed learner [50]. Here they describe that the difference between the two is that "instructional method processes" are part of the learning process, whereas "personality characteristics of the learner" define the self-direction of the individual learner. This relationship is what leads to the interactivity of the learning process within the adult learner; as they constantly absorb instruction to inform decision-decision making practices and inflect their own characteristics into the choices and decisions they make. To Brockett and Hiemstra, this process is what allows individuals to "assume ownership for their own thoughts and actions" as they work through decision-making processes and it is an element that adult education programs should integrate to ensure they allow learner to reflect on their prior knowledge and experiences thoroughly [50].

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Computer Technology and Application 4 (2013) 504-610

Integration of Computer Assisted Learning in Teaching and Learning in Secondary Schools in Kenya

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Received: September 6, 2013 / Accepted: September 18, 2013 / Published: September 25, 2013.

Abstract: The purpose of this study was to establish factors that lead to poor integration of Information and communication technology (ICT) for teaching and learning in schools in Kenya, despite comprehensive policy, institutional, infrastructural frameworks and capacity building by the Ministry of Education. The subject of this study was administered by use of questionnaires in three categories of public schools: national school, provincial schools and district schools. The respondents were students from each level that is from one, two, three and four and teachers based on the most offered subjects in the secondary schools. The computer assisted learning facilities were classified into computers, internet and content in optical media. In national school Internet based research, optical media content provided by Kenya Institute of Curriculum Development and Cyber School program for science subjects was used in learning. In provincial school, it lacks adequate computers, reliable Internet and content in optical media. In district school, it lacks adequate computer, no internet connection and content in optical media. A learner management system which can be accessed by all learners by use of any internet access devices like mobile phone access will be an ideal tool with over 4,000,000 mobile phone subscribers currently in Kenya.

Key words: Information and communication technology, computer assisted learning, internet.

1. Introduction

Computer assisted learning is a hybrid term that uses ICT resources to achieve teaching and learning goals. Although ICT has several definitions depending on the nature of its use, for this research, ICT is used as an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer, network hardware and software, satellite systems, as well as the various services and applications associated with them, such as videoconferencing, distance learning and learner and content management systems. We refer to ICT in the particular context of ICT provision, policy and teacher factors that variously support teaching, learning and a range of activities in education.

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The ways ICTs have been used in the education can be clearly divided into two broad categories: ICT for education and ICT in education. ICT for education refers to the development of information and communications technology specifically for teaching/learning purposes, while ICT in education involves the adoption of general components of technologies in the teaching process (more specifically, often for the training of teachers in the use of technology for teaching [1]. In a similar vein, UNESCO (United Nations Educational, Scientific and Cultural Organization) classifies ICT in education into three broad categories: pedagogy, training and continuing education in 2004. Pedagogy focuses on the effective learning of subjects with the support of the various components of ICT. It is emphasized that the pedagogic application of ICT involves effective learning with the aid of computers and other information technologies as learning aids, which play complementary roles in the classroom, rather than supplementing the teacher. The application of ICT in education is now making it possible for education to transcend space time and political boundaries.

The research approach will be on three methodology dimensions.

- The technological components;
- Learning model;
- Stakeholders;

1.1 Technological Components

Technological components refers to collection of technological tools (hardware and software) used to deliver learning materials and to facilitate communication among participants. They are further described as technological infrastructure-consisting of network infrastructure, application platforms and devices, and content-consisting of content creation, content packaging and content delivery.

1.2 Learning Model

It consists of an educational environment, course development, teaching and learning student interaction, collaborative learning, and evaluation and assessment.

1.3 Stakeholders

ICT is used in learning and teaching the stakeholders (partners and alliances) that include learner, teachers who assist in developing the course material, learners support, evaluation and testing, educational institutions that provide the platform, services and environment for learners and teachers to obtain what they need. The education institutions include the Ministry of Education and its departments like Kenya Institute of Education, Kenya National Examination Council, Kenya ICT Board, Kenya ICT Trust Fund and Vision 2030.

The paper is organized as follows: Section 2 discusses the initiatives and policies; Section 3 discusses methodology; Section 4 discusses barriers affecting integration of computer assisted learning in secondary schools Kenya. Section 5 presents the conclusion.

2. Initiatives and Policies

A national ICT policy for Kenya was adopted in January 2006 after many failed attempts in preceding years. The aim of the policy was to improve the livelihoods of Kenyans by ensuring the availability of accessible, efficient, reliable and affordable ICT services as reported in the ICT in education options paper. One important strategy outlined in this report is the promotion and development of specific e-learning resources that would address the educational needs of primary, secondary and tertiary institutions. A significant step in this direction is the digitization of the curriculum which is ongoing at the Kenya Institute of Education. In an effort to promote the development of content that will address the educational needs of secondary education, the government came up with two ways in which the curriculum will be developed: One is by adapting existing educational materials and distributing them to the schools; and the second is by beginning the process of having schools create their own e-content. In order to achieve this policy objective, the KIE (Kenya Institute of Education) has been singled out as the sole government body charged with the responsibility of developing the ICT curriculum as well as distributing the educational material. KIE would also be in charge of overseeing other institutions that develop appropriate e-content. Objective number 10 of the MoEST (Ministry of Education science and Technology) strategic plan which was running from 2006 to 2011 targets strengthening the capacity of KIE to execute this mandate among others. The realization of achieving the computer assisted teaching and learning is expressed in the national ICT strategy for education and training, the policy document for ICT in education. These include among others, (1) equipping education institutions with digital equipment to stimulate integration of ICT in education and (2) supporting initiatives that provide digital equipment to educational institutions, with priority to secondary schools [2]. The expected outcome of these measures was to improve equipping of educational institutions with digital infrastructure up to 80% in secondary schools. An ICT unit has been established at the Ministry's Head office to ensure systematic efforts are made towards strengthening adoption and use of ICT in the education sector in general. A main component of this implementation strategy is achieved through the Kenya ICT Trust Fund. Kenya ICT Trust Fund is a registered consortium in the form of a Non-governmental or Ganization (NGO) in Kenya that brings together many partners from the public, private and civil society sectors. It is chaired by the Permanent Secretary of the Ministry of Education. Its main objective is to mobilize funds for the sole purpose of setting up computer laboratories in all Kenyan secondary schools in 4-5 years. A number of initiatives have delivered ICT infrastructure to schools, mainly at secondary level. These include initiatives supported by parents, the government, NGOs, or other development agencies and the private sector. Notable among these are EMIS (education management information system), computers for schools—Kenya, NEPAD (new partnership for Africa's development) e-schools initiative, and the Microsoft Partners in learning program (Microsoft, 2007).

Other Initiatives include establishment of the learning resource centre that offers training in educational management and integration of ICT for school managers, lecturers, and students at the Kenya Technical Teachers College; a MoE (Ministry of Education) project "ICT equipment for schools" purchased computers for 142 schools in support of the ICT in education strategy; development of learning content focusing on digitization of curriculum content for schools at the Kenya Institute of Education; Kenya Education Network Trust (KENET), currently funded by the Kenyan Ministry of Education and the ICT Trust, established permanent high-speed internet infrastructure in 22 school broadcasting.

Free Software Licenses provide free access to Microsoft Corporation's operating software for schools and higher education institutions in order to reduce the cost of buying and using computers. The company was to work with the organizations involved in supplying computers to the institutions to install the software in the computers.

3. Methodology

This part describes the means of organizing the content for learning, the learning processes used and the support and impact on the stakeholders as used in integrating computer assisted teaching and learning in secondary schools in Kenya. Three categories are used to discuss the topic of research.

- The technological components;
- Learning model;
- Stakeholders.

3.1 The Technological Components

Teachers using technological infrastructure to deliver content to the learners are involved. These infrastructures are classified into computer as a resource, network infrastructure, application platforms and devices [3]. In Kenya, secondary schools receive annual facility development fund from the Ministry of Education with national schools getting the biggest share followed by the provincial school and the allocation is done in number of student ratio factor and ICT facility development is the key priority. All the national schools have an operational local area network and internet connection and computers are in a 1:1 and 1:2 ratios in some schools i.e.1 computer 2 students, with computers being Pentium III and above. The piloting of AVIDANET project of Ministry of Education was piloted in Nairobi School and The Kenya High School where learning was done through a local area network in a classroom environment. One of the major application platform used in schools more so national schools example of Nairobi School and Alliance High Schools is the Cyber School for science subject platform where the executable file is installed in the school server or independent personal computer and the various subject 3D animated content like experiments processes in Digital Versatile Disk (DVD) can be used for teaching and learning. Internet is used for research and uploading holiday assignments to the schools websites. The use of projector in teaching helps in display of internet researched materials, in animation, video, images and pictures.

Provincial schools also have local area network and internet facilities and computers as well some have website and these schools have higher priorities of development dedicated to ICT and computer use on teaching and mainly focus on the computer studies subject students. The computer ratios are 1:2 and 1:4 and others have 1:10 if the schools do not perform timely maintenance of the broken computers. There is use of projectors in some schools for display of teaching materials.

Districts schools lack adequate ICT facilities ranging from computers network infrastructure to computer studies subject as an examinable subject limit them to priorities funding in ICT; moreover their government annual funding is less compared to national and provincial schools.

3.2 Learning Model

Learning model is further categorized into three; content creation, content packaging, and content delivery. Kenya Institute of Education is the only mandated body to create, package, implement and review the curriculum of primary and secondary education in Kenya. Secondary school content is created by inviting various subject teachers and examiners to develop learning content according to the syllabus whereby scripts are written and edited for audio content recording and after verification they are packaged in optical disk mainly Compact Disk(CD). For the video content recording is done in various ways, it can be through a discussion of concepts by the subjects experts or live classroom teaching environment, like a science subject experiment where the processes is recorded or video shoot of features like in geography subject and images. Currently, Kenya Institute of Education has embarked on an ambitious task of developing a learner content management system with the new government mission of a Laptop per every child in school starting in year 2014 [4]. Stakeholders like Cyber School for science Subjects Company has the content in 3-D animated form where the concept is delivered in a better way for the learner to understand.

Content packaging and delivery is an important consideration when it comes to content development for learning. Currently KIE has only managed to package the content is in DVD and CD which are supposed to be purchased by school, and according to the research few national schools has managed to purchase and those that have been purchased they are not fully used to support teaching and learning for example Nairobi School has a set of all the subjects but only science subject teachers uses them to teach and for lesson review by the students. In provincial school the content is rarely used with exception of languages subjects' i.e. English, Kiswahili, and any other foreign language offered by the school and in district school only used for language subject as the case of national and provincial schools. However, as said earlier language subjects has a unique wide use of content in disk digital form whereby the set books taught in English Literature are acted by private companies and the school can borrow or purchase from the company and can be used in both computer and television. Other learning model involves the teacher using application packages like power point presentation to teach and for boarding secondary schools during holidays some teacher send assignments in the schools website for student do over the holiday.

3.3 Stakeholders

The major stakeholders in integrating computer assisted learning in secondary school in Kenya starts with the Ministry of Education that develops the policy, institutional, infrastructural frameworks and capacity building for teaching and learning, through giving mandate to KIE to develop content for computer assisted learning. The secondary school principal through the district education office are advised to purchase the content as stakeholder, for the teachers to use the materials for teaching and learning, the learners are the beneficiary of the process of computer assisted learning since with technology in teaching and learning there is more learning compared to the normal classroom environment. The perception of computer assisted learning by the school principal determines the level of integration. A number of studies have identified the school principal as a critical and pivotal person for 'establishing and maintaining learning environments compatible with student-centered approaches to teaching and learning with ICT'. They are also seen as curriculum and pedagogy leaders and are considered by stakeholders as central figures in leading processes for creating the conditions to teach and learn with ICT. From these arguments, it appears school leadership plays a key role in ICT integration in education. The competence of the school head in the use of ICT and a broad understanding of the technical, curricular, administrative, financial, and social dimensions of ICT use in education is important to the effectiveness and sustainability of ICT integration programmes.

4. Barriers Affecting Integration of Computer Assisted Learning in Secondary Schools Kenya

Use of computer assisted learning in teaching and learning may encounter many difficulties and these difficulties are known as "barriers".

4.1 Classification of Barriers

Several studies have divides barriers into two categories: extrinsic ones and intrinsic ones [5]. However, what they meant by extrinsic and intrinsic differed. In one study Ertner (1999) refer to extrinsic barriers as first-order and cited access, time, support, resources and training, and intrinsic barriers as second-order and cited attitudes, beliefs, practices, and resistance. Extrinsic barriers are regarded as pertaining to organization, rather than individuals and intrinsic barriers as pertaining to teachers, administrators and learners. Another classification was based on teacher-level barrier versus school-level barriers Becta (2004) such as lack of time, confidence and resistance to change or school level barriers such as lack of effective training, lack of enough resources. Furthermore the barriers can also be classified into resource, teacher-level, and school-level and management barriers.

4.2 Resource Barriers

Resources is limited in computer assisted learning such as computers, internet connectivity, and content in digital form, devices that support teaching and learning like the projector, speakers and optical disk readers and players.

4.2.1 Teacher-Level Barriers

- Lack of teacher confidence;

In Kenya, teachers lack of confidence in using computer in teaching and learning. Some studies have investigated the reason for teachers' lack for confidence, for example, eggs (2000) asserted that teachers "fear to failure" caused the lack for confidence, and limitation of teachers' ICT knowledge makes them feel anxious about using ICT in teaching Balanskat et al. (2006) while the learners could be having more skills than them.

- Lack of competence;

In secondary schools in Kenya, many teachers lack of skills and knowledge to use computer assisted learning whereby in secondary schools, this causes a barrier in adoption of computer in teaching and learning.

- Resistance to change and negative attitude.

Resistance to adoption of computer assisted material and continual text book use is a barrier in Kenya for computer assisted teaching and learning and resistance is caused by lack of technical support, poor planning on time schedule.

4.2.2 School-Level Barriers

- Lack of enough teaching time allocation;

The research indicated that many teachers have competence in using computers in the classroom, but they still make little use of technologies because they do not have enough time allocated for lesson in according to the timetable schedule. This attributes to the school management but not scheduling enough computer time for classes, the research time to explore sites to gather information, connecting devices and preparing the lesson in power point presentation form or in any other digital form, like photos and images.

- Lack of effective training;

Many teacher lack of training in the proficiency of using computer assisted learning in teaching and learning, such that they cannot be able to use basic devices like a computer and a projector to display or deliver a lesson.

- Lack of access to technology;

Research indicates that teachers lack accessibility of technological devices and other resource in school and at home attributed to high cost of facilities like internet connection and computers.

- School administration barrier.

If the school principal controls ICT skills or interest in learning the skills, the research indicated that the support to purchase and implementation ICT related resources will get minimum support from the principal as the decision maker and then the use cannot be achieved with minimum or no support.

5. Conclusion

The ICT policies in Kenya Vision 2030 have the use of computer assisted learning clearly defined and the Ministry of Education is mandated to work with the stakeholders to achieve this goal. The challenges faced by the Kenya Institute of Education which is the only organ mandated to develop update or review education curriculum for both primary and secondary education, like content packaging in optical media, can be solved by the recent objective of creating a web based on learner content management system which can be accessed in the mobile phone platform where currently there are over 4,000,000 mobile phone user in Kenya and there will be more confidence to access or to use the mobile phone as teaching or learning tool since there is more confidence in using the phone than computer. The cost of connection is also cheap in the mobile phone and also the charging power ratios can also be achieved easily, rather than where you need electricity connection to access the materials. The availability of open source programs like Moodle and Drupal can be used to develop simple and relevant learner management systems for learning by independent schools and the materials can be exchanged and shared among schools for diversity and this will reduce the haven burden of the Kenya Institute of Education which has and fosters the use of computer assisted learning in secondary schools in Kenya. The flexible mobile phone connection accessibility will also foster more interest since the mobile phone connectivity network is now over 80% in the country.

Lastly, the government should have a policy of supporting the digital content in other government institutions so that the culture can easily be adapted as a way of modern way of doing things for efficiency, time saving and good quality services.

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Computer Technology and Application
Volume 4, Number 9, September 2013
David Publishing Company
16710 East Johnson Drive, City of Industry, CA 91745, USA
Tel: 1-323-984-7526, 323-410-1082; Fax: 1-323-984-7374, 323-908-0457
http://www.davidpublishing.com
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ISSN 1934-7332