Lorna Uden
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Learning Technology for Education Challenges

6th International Workshop, LTEC 2017
Beijing, China, August 21–24, 2017
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Preface

New technologies have a powerful influence on all aspects of our society including education. Many technologies have an impact on the way we teach and learn. New mobile devices (e.g., smartphones and tablets) increase student engagement with applications such as mobile augmented reality. Social networks and Web 2.0 tools enable students to take a more active role in their own education, allowing them to become educational "prosumers" (i.e., both producers and consumers). Gamification, automation, big data, cloud education, MOOCs (massive open online course), social learning, adaptive learning, immersive learning, mLearning, personalized learning, and responsiveness are just some of the hot topics in this field. There is much research that shows learning technology has the potential to improve learning. Besides technologies, there are also new pedagogical advances in learning and teaching.

The 6th International Workshop on Learning Technology for Education Challenges (LTEC 2017) examined these technologies and pedagogical advances that are changing the way teachers teach and students learn while giving special emphasis to the pedagogically effective ways we can harness these new technologies in education. It brought together academic research and practical applications of education from all areas, seeking to gather top research and proven best practices together into one location, for the purposes of helping practitioners find ways to put research into practice, and for researchers to gain an understanding of additional real-world problems. These proceedings consist of 16 papers covering various aspects of technologies for learning including:

- Learning technologies
- Learning tools and environment
- Online learning and MOOCS
- Problem-solving and knowledge transfer

The authors of the papers come from many different countries, including China, Colombia, Denmark, Finland, Germany, Greece, Guatemala, Japan, New Zealand, Spain, UK, and USA. We would like to thank our authors, reviewers, and Program Committee for their contributions and Beijing Jiao Tong University, Beijing, China, for hosting the conference.

Special thanks to the authors and participants at the conference. Without their efforts, there would be no conference or proceedings.

August 2017

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Methodology for Teaching Electronic Instrumentation with Embedded Systems

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Abstract. The paper shows the design, implementation and testing of a system to measure voltage, current and energy in order to transmit them via web, Using the embedded Arduino® systems on which the different protocols learned during the electrical engineering study program are implemented, in order to evaluate the competences acquired by the students in the fields of instrumentation, communications, programming and web application development. The students who participate are in the last semesters of the Universidad Francisco José de Caldas in Bogotá, Colombia.

Keywords: Teaching embedded systems · Learning communication protocols · Electronic instrumentation · Arduino® · ADE7763

1 Introduction

The global competition of the 21st century has provided the design and development of innovative platforms to produce good thinkers from universities, which have been incorporated into the curriculum, to improve the learning of students with the union of embedded systems and engineering problems of the real world.

There are many devices available that allow mixing elements related to programming, communications and operating systems, which allow the development of electronic prototypes for didactic teaching methods in engineering with different applications as well as data analysis through the taking of signals, including: hardware platforms based on Python® as Rasberry PI® software allowing to add concepts of high and low level communications with operating systems [1],® PIC (Peripheral Interface Controller) created by Microchip® Technology Inc [2] are used in electrical circuits as small controllers and most have flash memory to reprogram [3], it is also the Arduino® development system [4], which has various predefined libraries, allows communication with the integrated, easy to use, program and integrate into educational environments because it adapts for use as a digital controller. The Arduino® platform provides an easy entry to teach students to acquire familiarity exploring details with the C programming language [5]. On the other hand are taught the subjects related to the transmission of the

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data to a web environment so they are read remotely, in order to teach the different technologies and communications protocol between them: HTTP, Ethernet, TCP/IP and protocols for Power Line communication (PLC).

2 Theoretical Framework for Embedded Systems

Some authors have proposed the use of the physical computing paradigm, in which the student interacts with the real world and takes computational concepts to learn to program as they must master language syntax, programming theory and problem solving techniques. The authors of the reference [6] explain this concept and reinforce it using embedded systems, with which there is a significant increase in the retention rate of programming courses. To raise learning competencies in the engineering curriculum the authors [7] introduced students to use technology platforms, developing their practical and design skills. The activity boosted motivation to acquire flexible knowledge as a creative problem solution, teamwork and communication skills.

There are many programming environments for circuits and electronic systems which retain imperative structures of programming languages that are not easily understood by students. A large number of platforms and embedded systems are available in the market for this reason digital control has become more accessible and cheaper. One of the most used is the Arduino® as it is easy to use, program and integrate into electrical projects providing an easy entry point to teach with templates and service routines that make the student acquire skill in programming [5]. The Arduino® platform tries to alleviate the programming load with its host system, just as it allows simple web access [8].

Other authors like [9] consider that this platform is highly flexible and equipped in terms of processor and electronics; It also has tutorials and examples available online,

Table 1. Characteristics of some Arduino® Boards (Source: [4])

Arduino® boards	Characteristics
Uno	Microcontroller ATM mega 320, 8 bits to 16 MHz. Flash Memory, 2 KB SRAM, 1 KB EEPROM. 14 digital pins
YUN	Native capacity Ethernet, Wifi, USF and Micro SD connection. 20 digital pins. Memory 32 KB
Leonardo	ATmega32u4 microcontroller. 32 KB flash memory. 20 digital pins
DUE	32-bit ATmel SAM3X8E microcontroller. 54 digital pins
Mega	Chip ATmega 256. 54 digital and 16 analogue pins
Arduino® Ethernet	It has electronic features such as the Arduino® ONE but with Ethernet connection capability and the possibility of connecting micro SD memory cards. 14 digital and 6 analogue pins
Fio	ATmega 328P microcontroller, has less memory, requires FTDO cable or an additional board. 14 digital and 8 analogue pins
Nano	ATmega168 microcontroller at 16 MHz, you need a mini USB cable, it does not have external power connector. 14 digital and 8 analogue pins

reducing the time for the professor to prepare classes and getting students to gain a hands-on experience with a collaborative classroom environment. Another important element is cost, since it is affordable and easy to achieve. By using Arduino® in the education process, its low cost allows to expand the number and type of possible experiments and combine several software technologies such as: C language, Matlab® to graph data, Simulink® to control the system, protocols for communications, AJAX and XML for client applications, among others [10].

For the job, there are different kinds of Arduino® boards to implement systems design and simulation environments in classes, Table 1 compares the characteristics of some of these which offer benefits depending on the type of micro controller, type of port, memory, among others.

2.1 General Model Proposed for Electronic Instrumentation

Based on the above considerations, it has been established as main objective to implement a system that allows the electrical engineering student to learn: Measure voltage, current, energy, process the signals to be transmitted via web and display them on a mobile device, so that student practice the knowledge acquired in the fields of instrumentation, measurement, communications, communications protocols and web applications. Figure 1 shows the relationship between themes and technologies.

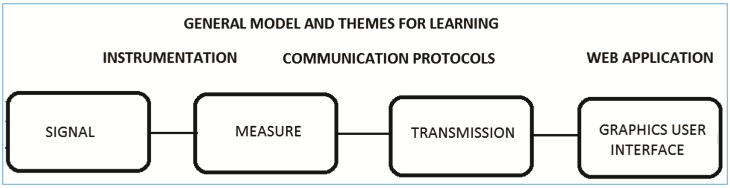


Fig. 1. General model and topics for learning. Source: Authors

For each of the topics covered, the student will implement a montage so that he can check what he has learned in each one of the topics related to instrumentation, measurement and monitoring of electrical systems.

2.2 Conceptual Model Proposed to Learn About Measurement and Communication on the Web

The conceptual model to teach and learn about: measurement of electrical signals, transmission and visualization of them in web environments, is shown in Fig. 2.

In the conceptual model shown in Fig. 2, it is possible to observe each of the components on which it is necessary to perform the experimentation so that the student can verify what is seen in the theory, beginning with the assembly of the signal system From the integrated circuit ADE7763, which allows to measure voltage and current, whose schematic diagram for tests suggested by the manufacturer is shown in Fig. 3, later the Arduino® system is shown, which processes the signals to be transmitted via SPI

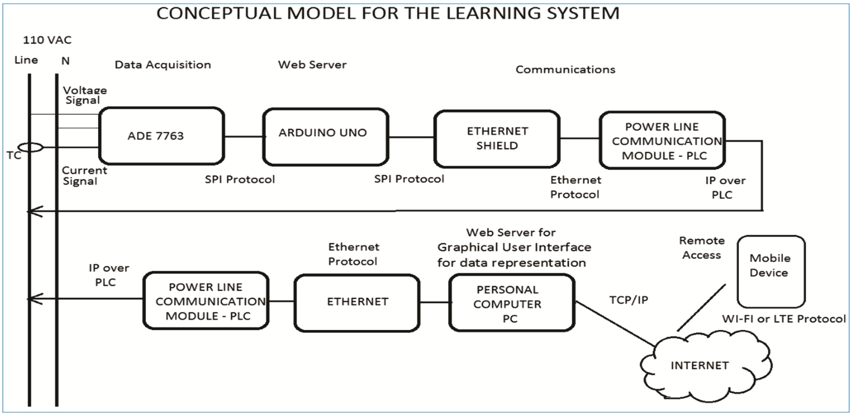


Fig. 2. Conceptual model proposed to learn about measurement of electrical signals. Source: Authors

protocol to the Ethernet Shield® card, to place the information on a TCP/IP frame, which is transmitted by the power line of the electrical installation where it is practiced using the PLC Modem.

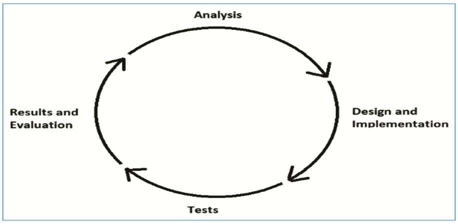


Fig. 3. Methodology for teaching to measure electrical signals with Arduino®. Source: Authors

Once the information is injected into the physical cabling, it is extracted by using a PLC Modem, doing the inverse process to retrieve the data signals and place it on TCP/IP protocol, to transmit it to a personal computer that has implemented a web server With high level protocol "http" and later publish it on the web, to be accessible from mobile devices.

3 Metodology and Analysis Approach

In order to emphasize in young students the need to work with physical environments programming was implemented the activity of taking electrical signals such as the voltage and current of an electrical device. For this, the ADE 7763 integrated circuit and the Arduino® board were chosen because it facilitates: obtaining the electrical signals and carrying out their calibration. Communication is done via Ethernet with a web server, for this function it is necessary to use the Ethernet Shield board, which is based on the Wiznet W5100 Ethernet chip, with a network (IP) supporting up to four socket connections Simultaneous [11], and executes a schedule to make the relevant communication. Figure 2 shows the methodology used to teach students how to take electrical signals through the integrated circuit ADE7763 and the Arduino® board, which took into account energy and current signals.

The sequential logic process to carry out the measurements is to take the signals, adapt them to the ADE 7763 and transmit them using SPI protocol to the Arduino®, for later transmission and access from the Internet.

The process that the student must follow is shown in Fig. 3 and includes this methodology: Analysis, design and implementation of the prototype, tests, results and evaluation of the operation of the system or subsystem.

3.1 Integrated Circuit for Measuring

For the signal acquisition it is necessary to choose the components that are part of the integrated circuit to obtain the value of the parameters of energy and current: transformers, resistive dividers, sensors [12] and other energy meters such as CS5464 [13]. The main objective of this stage is that the student to learn how to measure voltage, current and energy by taking the respective signals with two integrated circuits and transmitting it through pins 17, 18, 19 and 20 of integrated circuit ADE7763, using SPI protocol.

3.2 Current and Voltage Signal

For the acquisition of the current signal, an ACS714 sensor is used, which consists of a precise 2.5-V offset circuit with copper conduction path to generate a magnetic field. Students must design a signal conditioning circuit to match the selected gain as the maximum input value of 0.5 [V]; With the aid of a variable voltage transformer, a precision multimeter and a load, the current measurement with different voltage levels is started, obtaining an input for pins 4 and 5 of ADE7763 between the range of 0 and 0.5 [V]. The same procedure is used to take the voltage input signal, with the comparative tables the student assigns pins 6 and 7.

3.3 Power and Energy

From the signals of current and voltage, the student obtains the energy of the charge, applying the following formulate [14]:

Active Power measurement:

$$p(t) = V * I - V * I * cos(wt) \tag{1}$$

The active energy measurement is expressed as follows:

$$E = \int Pdt = \lim_{t \to 0} \left[\sum\nolimits_{n=1}^{\infty} p(nT) * T \right] \tag{2}$$

In this case the student learns to determine indicators from the measurements made, implementing in software the respective formulas.

4 Results

After realizing the design of the system for measurement and visualization, we proceeded to the implementation of each of the modules. The part related to voltage and current measurements is shown in Fig. 4.

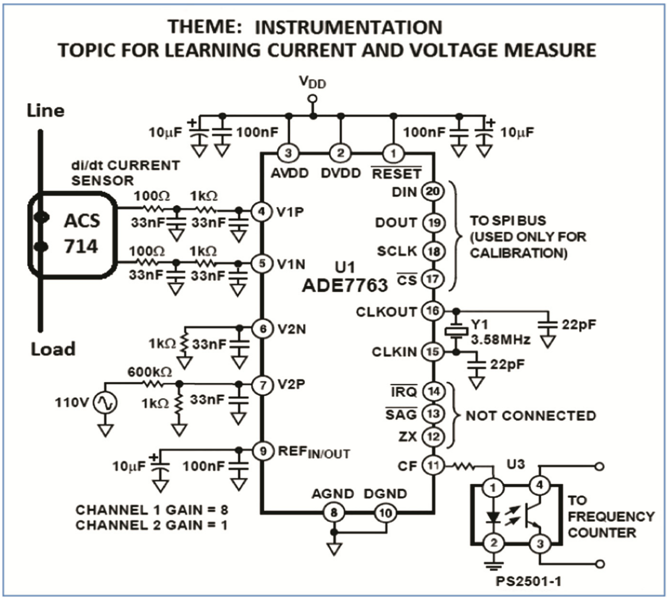


Fig. 4. Measurement System with ADE7763, for didactic purposes. [14]

4.1 Schematic Diagram for Voltage and Current Measurement

The ADE7763 is a device for measurement of the company Analog Devices [1], which has two channels (current and voltage), each with a programmable gain amplifier. It provides an interface for reading the data and a pulse output frequency (CF) proportional to the active power. Various features of the calibration system such as offset correction channel, phase calibration and power calibration ensure high accuracy; As well as detects variations of high or low voltage; In addition there is a great variety of documentation on this device.

With regard to current measurement, the market offers several options such as: Shunt resistance which provides an accurate current measurement [15], Current transformers (TC) [16], Hall Effect Sensor [17], Or the Rogowski Coil [16]. For class teaching exercises a Hall effect current sensor with reference ACS714 [17] was selected, eliminating the need for an external analog integrator for long term stability and accurate phase adaptation between current and voltage. It has different current measuring ranges such as ±5, ±20, ±30 Amperes, improves the precision detection of the system, operates with a simple source of 5 V and has voltage output proportional to AC or direct current. The complete system for the measurements provided to the student is shown in Fig. 4.

4.2 Communications System

The main objective of this process is to learn how to perform the communication process between the ADE 7763 m with the Arduino® board and the Ethernet Shield® module, using the SPI protocol.

4.2.1 Learning the SPI Protocol

Learning Serial Peripheral Interface (SPI) protocol is performed when the communication assembly between the ADE 7763, Arduino® and Ethernet Shield board is implemented. The process is shown in Fig. 5.

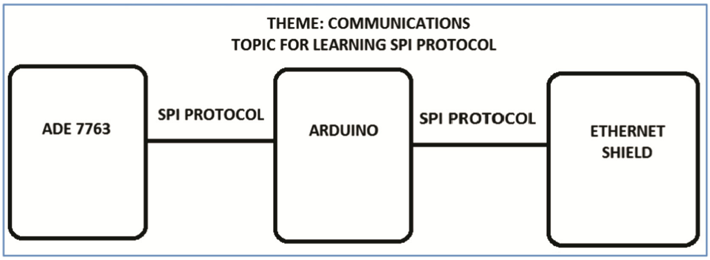


Fig. 5. Communication between ADE7763, Arduino® and Ethernet Shield®. Source: Authors

The student must perform an analysis of the communication system that comes by default in the Arduino® that is SPI, to interact with the ADE 7763. The first work with the SPI library included in the Arduino® is to analyze the modes of operation of the communication which range from mode 0 to mode 3; The second work is to analyze the dead times, which must be greater than or equal to 4 microseconds, according to the specifications of the ADE, with which the student implements the function “delayMicroseconds (4)” in the code. The configuration from the Arduino® software for SPI protocol is shown in Fig. 7.

4.2.2 Learning TCP/IP Protocol

The operation and learning of the Transport Control Protocol (Internet Protocol), is implemented through the communication between the Ethernet Shield® board, the module for power line communication (PLC) and the personal computer where the application for measurement system is hosted (Fig. 6).

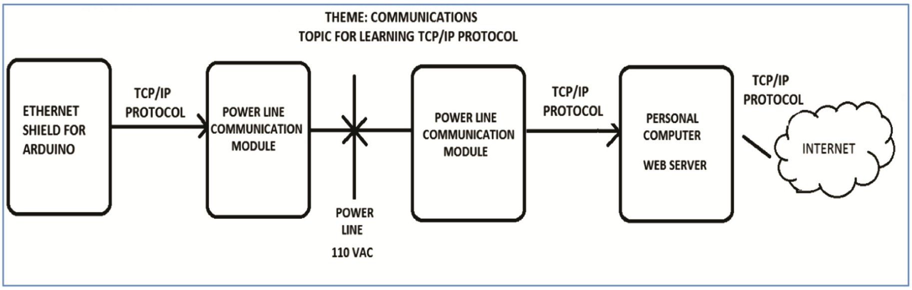


Fig. 6. Communication between Ethernet Shield®, PLC modem and personal computer. Source: Authors

The student must perform an analysis of the TCP/IP communications system from the Ethernet Shield® card, the Power Line Communications module - PLC and the personal computer where the software is hosted. The software on the personal computer allows visualizing the measurements made. The code for configuring the TCP/IP and SPI protocols mentioned above is shown in Fig. 7.

```
/*
 * Library for learn Communications Protocols with Arduino
 */
#include <SPI.h> // Library for use SPI Protocol with Arduino
#include <Ethernet.h> // Library for Ethernet
#include "PowerMeter.h" // Libray for Measure
#include "Pins.h" // Library for Arduino PIN configuration
#include "ADE7763Reg.h" // Library for Register of ADE 7763
#include "ADE7763.h" // Library for ADE7763 configuration
#include "ADE7763LL.h" // Library for ADE7766 configuration

byte mac[]={0xDE,0xAD,0xBE,0xEF,0xFE,0xED}; // Assign MAC
IPAddress ip(192,168,0,178); //Assign IP Adress for Server
EthernetServer servidor(80); // Port for Server

/************************************************************/
/* Set up routine */
/************************************************************/
void setup(void)
{
 SPI.begin(); //Start SPI protocol
 Serial.begin(9600); // Speed for Serial Port
/****************************/
/* Initialize SPI Bus       */
/****************************/
 SPI.setBitOrder(MSBFIRST); // Configure read order
 SPI.setDataMode(SPI_MODE1);   // Assign SPI Mode
 SPI.setClockDivider(SPI_CLOCK_DIV4);// Assig Clock Frecuency
/************************************************************/
 * Main loop
/************************************************************/
void loop(void)
 {
 Ethernet.begin(mac, ip);  // Begin Ethernet Communication
 servidor.begin(); // Start HTTP Server
 float v1,v2,c1,c2, E1, E2; // Declare variables for voltage,
                            //Current and Energy.
*****
*****
}
```

Fig. 7. Source code for measure and communication with Arduino® board. Source: Authors

The previous application is executed on the Arduino® board, allowing to realize voltage and current measures, which Web page are visualized.

The way to invoke the service is through high level "HTTP" protocol, pointing to the IP address 192.168.0.178 and whose results are observed in the Fig. 8. The page is in Spanish, native language of students.

Fig. 8. Application running on the Arduino system. Source: Authors

4.3 Implemented Systems by Power Line

For this purpose a commercial modem of the TP-LINK® 300 Mbps was used, which is shown in Fig. 9.

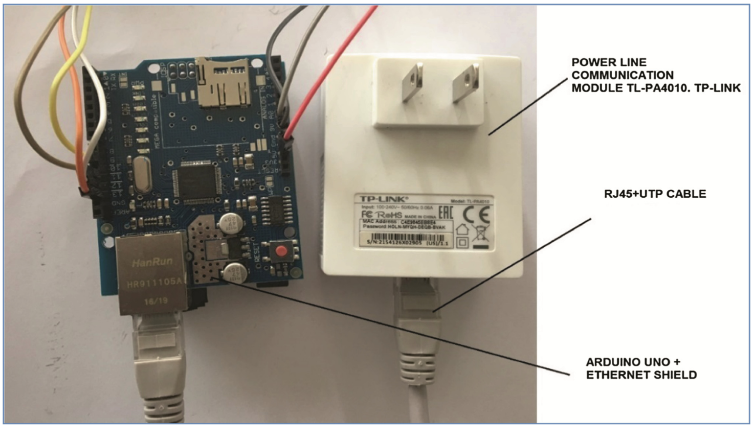


Fig. 9. Power line communication and Arduino® board. Source: Authors

The complete system consists of voltage and current measurement systems, communications protocols, power line communications and the processing unit that corresponds to the Arduino® system.

4.4 Web Application for System Management and Data Visualization

A web application with Active Server Pages technology was implemented to allow remote management through the web using mobile devices or desktop computers. In Fig. 10, you can see the application in operation. The page is in Spanish, native language of students. This application can be accessed from any smart mobile device through Wi Fi protocol.

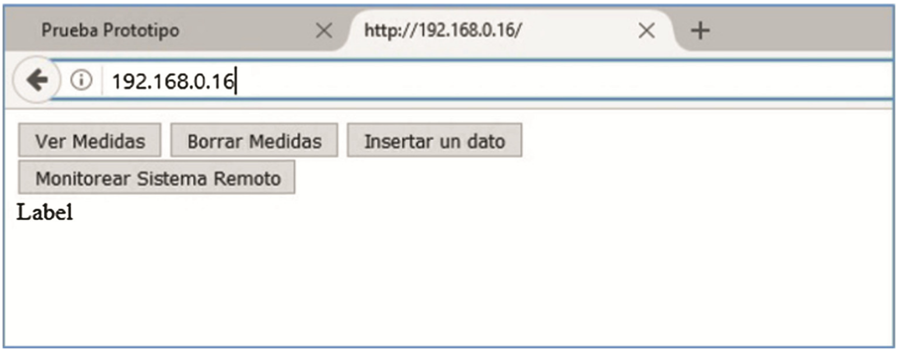
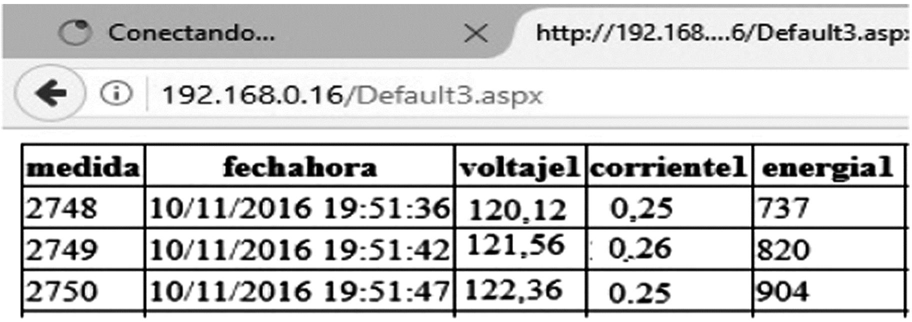


Fig. 10. Web application. Source: Authors

In the application that is implemented on the server can be access the measurements for each of options shown on buttons. For example, when you press "Ver Medidas", means Show Measures, the data shown in Table 2 are observed.

Table 2. Data corresponding to the measures. Source: Authors.



Conectando...
http://192.168....6/Default3.asp:
192.168.0.16/Default3.aspx

medida	fechahora	voltajel	corrientel	energial
2748	10/11/2016 19:51:36	120,12	0,25	737
2749	10/11/2016 19:51:42	121,56	0,26	820
2750	10/11/2016 19:51:47	122,36	0.25	904

5 Discussion

The assembly process of these systems was realized for six students of 9 and 10 semester of electrical engineering of the Francisco José de Caldas District University in Bogotá DC, Colombia, who autonomously carried out the assembly and follow this methodological process: Requirements analysis, electronic designs, software design, electronic systems implementation, software implementation for the Arduino® system, software implementation for the web system, subsequently the tests were carried out with voltage and current measurements, the communication between the ADE7763, Arduino® and the server was tested with Web application, where the results were stored in a database in order to verify the complete system operation.

Proposed objectives have been achieved during the learning process. The greatest difficulties are related with the software development, especially the reading of the measurement system records, which was necessary to implement them in programming language *C*. On the other hand the web application development for the server that required Visual Studio .NET 2013® development tool.

Related to measurement, accuracy was approximated to 3%, compared to a standard meter of class 0.1 used in laboratories. At first glance this error could be high. It should be taken into account that the objective of this research was not to make a meter, but to put into practice the knowledge about instrumentation, communications and web applications. It took approximately one (1) year for students to complete the assignments, but with the above, students competences were evaluated to design, develop and implement systems that require knowledge of different areas.

6 Conclusions

The Arduino system allows to easily implement a web server, accessible from HTTP protocol, which allows data to be placed on the Web and makes it useful for future work related to measurement, supervision and control in electrical systems in the context of Internet of Things.

It can be seen that results for electrical measurements close to 3% are too large for precision purposes, the most important objective of this exercise was to put into practice the knowledge about communications and protocols learned during the development of the electrical engineering program.

The students had a great difficulty implementing the different modules because they had to acquire additional skills to those imparted in the training such as: learn to weld, interact with physical elements such as resistors, capacitors, safety aspects in connecting components to prevent burned by bad connections, especially the risks of working in the same environment high voltages (120 VAC) and 5 VDC.

The tests and calibration of the measurement system was very important because it was necessary to apply linear regressions to be able to do the characterization of the same. The best thing about this aspect was to see the direct relationship between theory and practice.

An important aspect of the work is that the students made their own developments, such as the measurement system with the ADE7763 circuit and the integration of the ACS 714 circuit, which integrated with commercial components ready to use as was the TP-LINK device for Communication by power line. This is important because devices like the TP-LINK can facilitate the implementation of systems quickly and the low cost.

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Designing of a Radio Link to Improve Web 2.0 and Internet Access in Rural Zones in Colombia. Case Study: E-Learning to the Indigenous Community of “Santander de Quilichao and Toribio Cauca”

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Abstract. In the Framework of the Community Program stations and internet access for indigenous people; this study introduces an overview of the feasibility studio and definition of technical conditions for the installation of a link between the broadcasting station of the municipality of Santander de Quilichao with a radial production center of Toribio’s municipality. The relevant aspects of the links design, as well as defining technical conditions to visit these areas, determining the location of the links, repeaters and some calculations made for this purpose and thus, how they can possibly access to e-learning Web 2.0 tools based on LMS basically in the area of indigenous communities of Toribio, Cauca’s County in Colombia.

Keywords: Data radio link · Indigenous communities · ITC · Web 2.0 · E-learning

1 Introduction

This paper was made in the frame of the community program between the Technologies of Information and The Communication Ministry. The Culture Ministry and the Financial Background of Development Projects Team, that supports the strengths, the recuperation and the conservation of the culture, its traditions, customs, languages and autochthonous life plans of Colombian Ethnic Minorities (indigenous people) [1], all of these through the provision of sound broadcasting infrastructure of public interest, whose operation is sustainable and guarantees the participation of the majority of sectors inside the ethnics groups. In this way, the link design and implementation for one of the stations between Santander de Quilichao y Toribio municipalities seeks to consolidate the above described project from Cauca providing an infrastructure that allows the foundation of the Radio Paýumat station that will have around 24.475 indigenous and benefits its population with a coverage of 16 reservations denominated “association of north zone of Cauca indigenous council” [2].

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The purpose was performed by an inspection and visits of the involved zones in the project and to analyze the land conditions (surrounded areas, accessibility, transport, isolation, media access and development resources, for instance: electric energy and other services) after the parameter identification and the definition of the technical conditions of the link also, to make a comparison between the project techniques definitions and requests which can determine the feasibility of this link and after that, the results shown and the conclusion of this project.

1.1 Definition of the Technical Conditions and Studies of the Zone

To make a definition of the technical conditions it is necessary to evaluate some factors such as: location, height, antennas elevation, potency and frequency of the station operation for the zones involved which are divided in 3 links:

- Link 1: Toribio (Transmitting End) y San Julian's Hill (Repeater System)
- Link 2: San Julian Hill (Repeater System)–Pýumat Transmitting (Munchique's Hill)
- Link 3: Pýumat Transmitting (Munchique Pequeño Hill) (Repeater system) – Pýumat's studio (Santander de Quilichao) (Receiving End).

These conditions are summarized in the following tables (Fig. 1):

Link 1: Toribio studio (Transmitting End) y San Julian Hill (Repeater system)			
Location Toribio studio:	**Indigenous House, Toribio.**		
Coordinates Toribio studio:	Datum Level Bogotá, ref. West	X= 818.630 m	Y=1´090.030 m
	Geographical Datum WGS84	Lat. N 2° 57´20.6"	Leng. W 76° 16´4.15"
Field Height Toribio studio:	1697 m.a.s.l		
Antenna Height Toribio Studio:	5 m		
Azimut Antenna Toribio Studio:	315.6°		
Antenna Elevation Toribio Studio:	10.7°		
Gain and type of antenna Toribio Studio:	6 dBi, yagui		
Power Operation (EIRP):	94.52 W		
Transmitter power:	10 W		
Link frequency:	It should be allocated by the technologies of information and communication ministry It worked in the band 335.4 - 343 MHz (339 MHz frequency).		
Coordinates San Julian Hill:	Datum Level Bogotá, ref. West	X=820.741 m	Y=1´087.942 m.
	Geographical Datum WGS84	Lat. N 2° 58´ 29.4"	Long. W 76° 17´ 11.7"
Heightfield San Julian Hill:	2262 m.a.s.l.		
Antenna Height San Julian hill:	10 m		
Azimut receiving antenna San Julian Hill:	135.6°		
Elevation receiving antenna San Julian Hill:	-10.7°		
Gain and type of receiving antenna San Julian Hill:	6 dBi, yagui		
Minimum receiver sensitivity:	1 mV, for composite signal		

Link 2: San Julian hill (Repeater system)- P´yumat transmitting (Munchique Pequeño Hill)(Repeater System)			
Coordinates San Julian Hill:	Datum Level Bogotá, ref. West	X=820.741 m	Y=1´087.942 m.
	Geographical Datum WGS84	Lat. N 2° 58´ 29.4"	Leng. W 76° 17´ 11.7"
Field Height San Julian Hill:	2262 m.a.s.l.		
Antenna Height Toribio Study:	10 m		
Azimut transmitting Antenna San Julian hill:	250.7°		
Transmitter Antenna Elevation Angle San Julian hill:	0.65°		
Gain and type of transmitting antenna San Julian hill:	12 dBi, yagui		
Power Operation (EIRP):	146.4 W		
Transmitter power:	10 W		
Link frequency:	It should be allocated by the technologies of information and communication ministry It worked in the band 335.4 - 343 MHz (339 MHz frequency).		
Transmitter coordinates P'yumat (Munchique Pequeño hill):	Datum Level Bogotá, ref. West	X=815.541 m	Y=1´073.016 m.
	Geographical Datum	Lat. N 2° 55´ 40.3"	Leng. W 76° 25´ 15.1"
Field Height Munchique Pequeño:	2462 m.a.s.l.		
Height Receiving antenna Munchique Pequeño hill:	10 m		
Azimut Receiving Antenna Munchique Pequeño hill:	70.7°		
Receiving Antenna Elevation Angle Munchique pequeño hill:	-0.79°		
Gain and type of receiving antenna Munchique pequeño hill:	12 dBi, yagui		
Maximum sensitivity receiver:	1 mV, for composite signal		

Fig. 1. The relationship between Links 1 and 2.

The considerable distances and the limited land access shapes a critical factor that can be important obstacles at the moment of making a red planning [3]. Therefore, in the first step of the project was made a studio of the zone to obtain information about the access and characteristics related to the infrastructure. The visited places were in the municipalities of Toribio, San Julián's hill, small Munchique's hill, and in Pýumat (Santander de Quilichao), where the dates are coined in the following Fig. 2 as follows:

Toribio Studies Infraestructure	
Access	Time from Santander de Quilichao to Toribio two hours, half of the route is paved road, the other half by dirt road in good condition.
Infrastruc-ture Studies Area	Studies are available in Services of Water and Power (single phase). There are some studies which are located on the second floor of the Indigenous House, which feature ceiling Composite triplex and polystyrene. We recommend installing a voltage stabilizer and surge and ground system.

Infraestructure San Julian hill (Repeater System)	
Access	Access path from Toribio takes 90 minutes. Today is a guarded area by the army. You must request permission to access the site.
Infraestruc-ture San Julian hill area	There is a TELECOM self-supporting tower 60 m and another 10m tower belonging to the indigenous community. There shed belonging to the indigenous community, you must provide a rack or holder for placing equipment there. Service is available Electric Power enough to feed the repeater system (single phase, 25 kW). You must install the system ground to the house of the indigenous community, voltage stabilizer and surge. To install the antennas can be used either towers are in place, but preferably to use the tower of 10 m, which would require repair you the reins and paint. To this point the line of sight to the Munchique hill verified through binoculars.

Infraestructure Munchique Pequeño hill (Repeater System)	
Access	Paved access road from Santander de Quilichao about 1 hour. Then you must walk 15 minutes up with strong inclination. In the place the transmitter station is installed P'yumat.
Infraestruc-ture Munchique Pequeño hill area	There is a tower of 30 m in which the antenna system of the transmitter and stand P'yumat is installed. it is recommended installing , stabilizer and surge voltage to be used by the radio relay system , you must also install a rack or stand to place there the transmitting equipment and radio receiver To install the radio relay antennas can be used tower It exists at the place . To this point the line of sight with the studies was not verified and currently operates a radio link with P'yumat studies additionally the day of the site visit the sector remained cloudy

Infraestructure P´yumat Studies (Santander de Quilichao)(Receiving End)	
Access	Access by paved road from Cali to Santander Quilichao about 2 hours.
Infraestruc-ture P´yumat radio studies area	There is a tower of 10 m in which the radio link system is installed at Cerro Munchique of P´yumat station. To this point the line of sight to the Cerro Munchique Small was not verified and currently operates a radio link with the aforementioned hill.

Fig. 2. Summary data survey in rural sites in Cauca.

1.2 Research Location Conditions Links

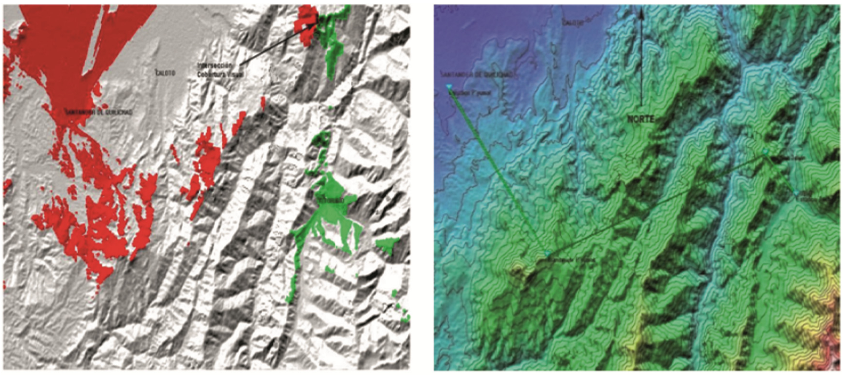
The location and determination of radio link point is between the site of the survey in Santander de Quilichao and Toribio zone; this condition is made by taking into account, among others established considerations and following the invitation to make the quote of the studio technique:

- Any individual who wants to visit or to work, he or she must take into account that has to know the steps in the indigenous communities where the station and the link system are developed and also he or she has to have a respectively consent of the representative of traditional authorities and it must be coordinated between the contractor and the respective indigenous community authority to carry out any kind of activities.
- With respect to the previous consideration, the same indigenous community represented by Mr. Leonardo Jurado who suggests the places, the location of the repeaters systems, even it was signed a record in which the community was compromised to ensure the availability, in the same way, the technical visit to the zone was made with the support and accompaniment of Mr. Jurado.
- The selected place for the establishing of the radio link constituent points must count with electrical energy provision.
- In all the radio link constituent points this condition is accomplished.

- It must exist an access facility in the selected place for the installation of the repeaters systems.
- The San Julian's hill is the unique place chosen for the radio link that doesn't have highway access. A person should walk around 90 min to get there, however taking into consideration that the reliability of the link system is high, this condition is not an impediment for installing there a repeater system.
- The selection of the landmarks for studies and transmission systems must seek zones with the best possible security conditions, in such a way that decreases the damage or robbery risk of the equipment that will be used.
- The place called Munchique's hill has already communications equipment installed for the community program and its construction in where they were installed is quite safe.
- Currently, the place San Julian's hill is guarded by the National Army. However, it is necessary to analyse if its presence will be permanent. Anyway, at present are installed communications systems of Telecom and safe booths.

2 Scheme Radio Link Physical Configuration

The establishing of a certain number repeaters, it was used a free software tool in which starting of the studio location of both stations. Then, it was determined the visual coverage zones that were achieved since those points, as a first conclusion it was found that it did not exist a looking line between both points as the one shown in the Fig. 3a.



(a) (b)

Fig. 3. Visual (a) and coverage area (b) between Santander of Quilichao and Toribio.

In Fig. 3, it is shown the visual coverage from the studio of the station of Santander de Quilichao (Radio Pýumat) this is shown in red and the Toribio's station. Additionally, there is a little area in that was transplanted into both visual coverage areas of each studio and therefore, it was used just one repeater, this area is located far from the wanted link points (23.8 km of the Radio Pýumat studio and 12.5 km from the Toribio studio). Besides, of having a very difficult access to the highway since the nearly road cross is about 5 km far from the point and it does not exist energy supply because of this, it is not practical to install a repeater there. Taking into account this situation, there were installed 2 repeaters to achieve the link. Then, it is taken like installation place of a repeater the location in which is found the irradiant system of the station Radio Pýumat (Munchique Pequeño) place that counts with electrical energy, access facilities and it is safe.

To set up the second repeater, it was taken the place in that it was going to be located a microwaves system of TELECOM located at 2.7 km from the Toribio studios (San Julian's hill), to reach that place, it must be by walking or riding a horse, it takes around 1 h and 30 min time, the place also counts with electric energy and enough security because it is guarded by the National Army soldiers, so it is also necessary to ask for permission to that institution to reach that place. Both choices to locate the repeater systems has a visual line between itself and at the same time the San Julian hill has a visual line with the place where there will be located in Toribio, Small Munchique studio and the Radio Pýumat Station. The scheme is the radio link physical configuration as shown in Fig. 3

2.1 Establishing the Radio Link Location Sites

The location coordinates of the constituent radio link sites are determined by (Fig. 4):

Datum WGS84 Coordinates		
Geographical	Latitude N 2° 57'20.64"	Longitude W 76° 16'4.15"
West Origin Level	X= 818.315 meters	Y=1'090.401 meters

Datum Bogotá Coordinates		
Geographical	Latitude N 2° 57' 30.9"	Longitude W 76° 16' 16.24"
West Origin Level	X= 818.630 meters	Y= 1'090.030 meters

Height above sea level:	1697 m

Datum WGS84 Coordinates		
Geographical	Latitude N 2° 58' 29.4"	Longitude W 76° 17' 11.7"
West Origin Level	X= 820.426 meters	Y=1'088.313. meters

Datum Bogotá Coordinates		
Geographical	Latitude N 2° 58'39.67"	Longitude W 76° 17' 23.69"
West Origin Level	X= 820.741 meters	Y= 1'087.942 meters

Height above sea level:	2262 m

Datum WGS84 Coordinates		
Geographical	Latitude N 2° 55' 40.3"	Longitude W 76° 25' 15.1"
West Origin Level	X= 815.221 meters	Y=1'073.386 meters

Datum Bogotá Coordinates		
Geographical	Latitude N 2° 55'50.57"	Longitude W 76° 25' 27.07"
West Origin Level	X= 815.541 meters	Y= 1'073.016 meters

Height above sea level:	2462 m

Datum WGS84 Coordinates		
Geographical	Latitude N 3° 00' 17.8"	Longitude W 76° 28' 52.8"
West Origin Level	X= 823.742 meters	Y=1'066.658 meters

Datum Bogotá Coordinates		
Geographical	Latitude N 3° 00' 28.06"	Longitude W 76° 29' 4.76"
West Origin Level	X= 824.056 meters	Y= 1'066.288 meters

Height above sea level:	1079 m

Fig. 4. Coordinate Munchique Small hill area and transmitter Pýumat, Repeater System and final system.

3 Propagation Budget

The propagation calculations are made based on the recommendations of the ITU-R PN: 525-2. Calculation of attenuation in free space and P.530-9 Propagation data and prediction methods required of a design of terrestrial sight systems [4]. The operating frequency band will be prepared by the Technologies of Information and

Communication Ministry, it is from point-to-point links with a channel width of 200 kHz, 390–400 MHz. It was also chosen a specific frequency of 395 MHz. and 390–400 MHz, as specific frequency of 395 MHz was chosen, however the calculation is performed in a band of 335.4–343 MHz, the frequency changing does not involve changes on the characteristics of the equipment.

The antenna heights were given to have an eye contact line in each link and it must have a clearing of the first Fresnel zone at least of 60% to be determined. (Rec. P.530-9). A software was used to determine the condition and it should take into account the field's profile and radius k factor of the Earth; where k in this case, is taken as 4/3 and frequency [5]. The clearing condition was especially due to considering the link between studio of Toribio and San Julian Hill in both parts, thus, the condition of both is largely due to geographical conditions.

Once determined the antenna height and secured the line of sight condition, it can apply the equations for calculating a free space loss according to PN Rec. 525-2 and it is related to point-to-point:

$$Lbf = 32,4 \quad 20\log \qquad 20\log d(\mathrm{dB}) \tag{1}$$

$f = frequency$ (MHz)
d = *distance* (Km)

The FSPL expression (1) above often leads to the erroneous belief that free space attenuates an electromagnetic wave according to its frequency.

Based on the propagation in free space, we can use the following conversion equation [6]:

$$E = P_t - 20\log d \qquad 74,8 \tag{2}$$

The Isotropic received power for a given field strength; where:

P_t: Isotropically transmitted power (dB(w))
P_r: Isotropically received power (dB(w))
E: Electric field intensity (dB (μV/m)
f: Frequency (GHz)
d: Radio electric path length (km)
Lbf: Basic Transmission loss in free space (dB)

The Eq. (3) relating the field strength necessary to the sensitivity of the equipment is:

$$E = K + V_r \tag{3}$$

The sensitivity, is the minimum magnitude of input signal required to produce a specified output signal having a specified signal-to-noise ratio.

where:
V_r: Sensitivity (dB μV)
K: Antenna Factor (dB/m)
For an input of 50 Ω receiver has a factor of antenna:

$$K = 20\log f - G_{ant} - 29,78$$

where:

G_{ant}: Antenna gain (dBi)

K: Antenna Factor (dB/m)

The budget about radio link between Toribio and Cerro San Julian was determined by an antenna height of 5 m studies in the Cerro San Julian of 10 m and it has to be the clearing of the first zone Fresnel which is 150% so that, the condition for free space propagation is satisfied.

For values of 339 MHz and a distance of 3.03 km losses in free space are in:

$$Lbf = 96,63 \text{ dB}$$

The transmit power should consider the cable losses and antenna gain:

For the frequency of 339 MHz ½ inch cable LDF12-50 reference in the catalog presents an attenuation of:

$$A_{cablef} = 1.114 \text{ dB}$$

For a transmitter located in Toribio studios, one wire length of 12 m so, it has an estimated attenuation (4):

$$L_{cable} = \frac{L_{ongcable} * A_{cablef}}{100} = 0.134 \tag{4}$$

It should also be considered the loss connectors which are made of 0.2 dB. Then, the losses transmission line are:

$$L_{lineatx} = L_{cable} + L_{connectors} = 0.334$$

Thus, the power transmitted by taking into account the losses of the transmission line including an antenna gain of 6 dBi:

$$P_t = 10 * \log\left(\frac{10\ watt}{1\ watt}\right) - L_{lineatx} + G_{ant} = 15,666 \text{ dB} \tag{5}$$

The equivalent value in watts Pt is known as EIRP (Effective isotropically radiated power) and it is:

$$EIRP = 10^{\frac{P_t}{10}} watt = 36,886\ watt$$

Then, the field strength obtained in the Cerro San Julian to an antenna gain of 6 dBi, a distance of 3.03 km and it is the power calculated above:

$$E = P_t - 20\log(d) + 74,8 + G_{ant}$$

On the other hand, it must be determined that the field strength should be in the Cerro San Julian to the receiver operates in proper condition, according to catalogs link receiving equipment have values between 50 μV up to 1000 μV. It works so that the worst case is that, of the highest signal that is required 1000 μV.

Again, taking into account losses transmission line on the receiving side, here the antenna has a height of 10 m, so that the transmission line is estimated at 13 m, then for cable LDF12-50 connector losses of 0.2 dB:

$$A_{cablef} = 1,114 \text{ dB}$$

$$L_{ongcable} = 13$$

$$L_{cable} = \frac{L_{ongcable} * A_{cablef}}{100} = 0,145$$

$$L_{connectors} = 0,2$$

$$L_{lineatx} = L_{cable} + L_{connectors} = 0,345$$

The sensitivity in dBμV from 1000 μV sensitivity value is:

$$Sensitivity \text{ dB}\mu\text{V} = 20log\left(\frac{1000 * 10^{-6}}{10^{-6}}\right) = 60$$

The field strength required for the receiving equipment is working properly:

$$E_{requested} = \left(20\log f - G_{ant} - 29,78\right) + Sensitivity \text{ dB}\mu\text{V} + L_{lineatx} = 75,169\frac{\text{dB}\mu\text{V}}{\text{m}}$$

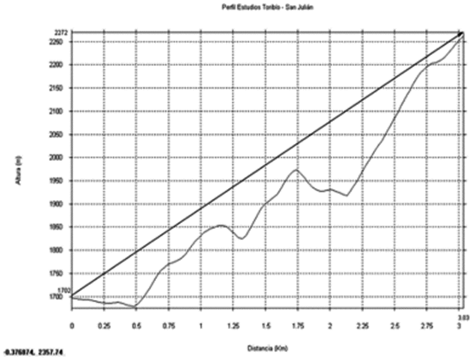
Because of this, the field obtained at the point of reception is greater than required conditions, it shows that the radio link for operation are met.

4 Plot Links Result

Then profiles between different points system involving the link values with the calculations are shown below:

Figure 5 shows the result of the 3 km link, this radio link is adequate and allows you to see that it has no problems with the Fresnell zone.

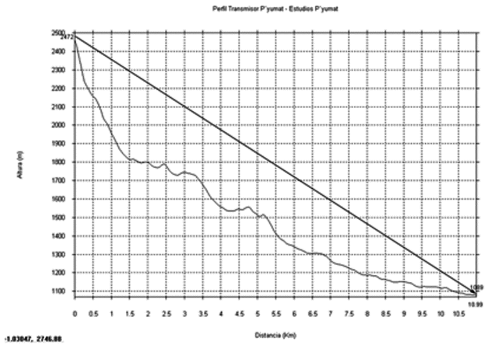
Figure 6 below shows the link from the hill Pýumat to the city of Toribio, it is also observed that the conditions are adequate and therefore the link can work properly without problems.



Transmitter Tower height (m)	Tower height receiver (m)	Worst clearing distance (km)	Worst Clearing First Fresnel Zone (%)
5	10	2.7	150
5	10	2.7	160

Frequency (Mhz)	Radio link distance (Km)	Transmitter power (w)	Gain antennas (dBi)	EIRP (w)	Lost Free Space (dB)	Field strength at the receiver (dBμV/m)	Receiver sensitivity (μV)	Required field strength at the receiver (dBμV/m)
339	3.03	10	6	36.9	94.6	84.84	1000	75.17
395	3.03	10	6	36.8	96	80.82	1000	76.6

Fig. 5. Link profile and calculations Toribio Studies - Cerro San Julian



Transmitter Tower height (m)	Tower height receiver (m)	Worst clearing distance (km)	Worst Clearing First Fresnel Zone (%)	Frequency (Mhz)
10	10	10.9	220	339
10	10	10.9	240	395

Frequency (Mhz)	Radio link distance (Km)	Transmitter power (w)	Gain antennas (dBi)	EIRP (w)	Lost Free Space (dB)	Field strength at the receiver (dBμV/m)	Receiver sensitivity (μV)	Required field strength at the receiver (dBμV/m)
339	10.99	10	12	146.4	105.8	75.64	1000	69.17
395	10.99	10	12	145.9	107.1	75.62	1000	70.51

Fig. 6. Link profile and calculations Cerro San Julián – Transmisor Pýumat.

Figure 7 below presents the profile of the terrain. It is possible to see the distance between the hills and the height at which the radio link is going to work. Here we show the utility of the computer tools that allow us to model the behavior of the links and how you can use the technical part with the distance teaching part.

The views of the radio links obtained are as follows land performance:

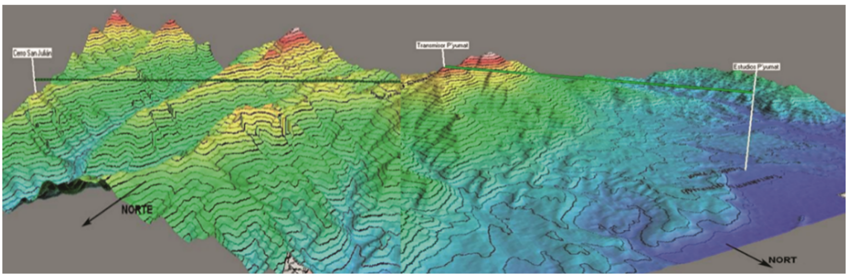


Fig. 7. View full Radio Link.

5 Web 2.0 LMS Tools Proposed to Cauca Indigenous Council

The inclusion and access to Web 2.0 platforms [8] is one of the key aspects in the information age and access to knowledge, the indigenous community of Toribio is located in a rural area of difficult access and does not have adequate access to the Internet connection. After performing the calculations presented above, teaching is done to use the Web 2.0 type tools. To achieve this, the research is performed on various platforms of web sites in the easy-to-use, cheap, widely supported, English and Spanish languages with multiple applications that can be installed quickly and intuitively [9].

The fundamental objective of the radio link is to have a communication with a network layer level since there is currently no connection of this type, once designed outdone by experts from the Universidad Distrital it is possible to teach the Web 2.0 tools, starting with courses of 120 h by using platforms such as: Moodle, Jommla, Jcow, and Commerce.

The best applied Cloud Computing solution for this, has about 14 websites were reviewed in English and Spanish, from which 2 of them were selected in Spanish and with applications in the cloud [10], Nixiweb and Hostinger, Nixiweb are adequate but it has some continuity faults of the site, for instance, Hostinger allows the installation in a few seconds of applications to create sites quickly and safely [11] (Fig. 8).

Fig. 8. View of Web 2.0 Hosting in the Cloud and free use tools. (Source: Hostinger (2016)).

The educational portal e-learning is made with Moodle with all its tool set, in the cloud hosting, it can be clicked and installed in less than a one minute, without using the classic structure with physical servers (Fig. 9).

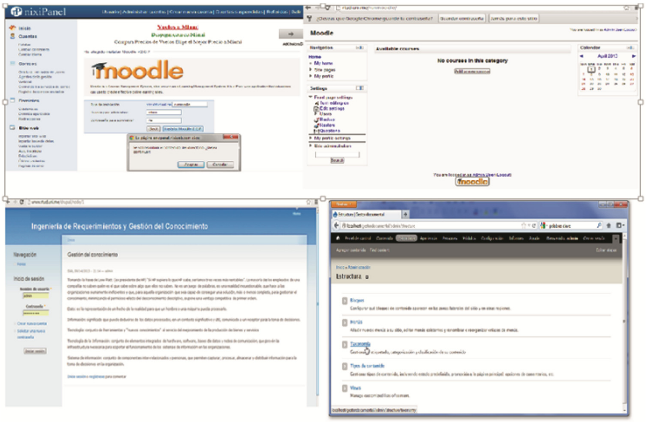


Fig. 9. Examples of learning applications of Web 2.0 Moodle and Drupal tools.

6 Conclusion

The developed radio link work was implemented and it is currently in operation benefit in 16 indigenous reserves, ensuring communication between their native languages and helping to preserve their culture, customs and relations as indigenous communities, a project like this materializes social inclusion of minorities and helps to reduce this digital gap in the nation. In the last two years, thanks to the progress of the peace agreements, there has been a significant advance in the incorporation of Web 2.0 and the use of ICT by the indigenous communities of Colombia and the case of the Region of Cauca. According to this, with the installation of a radio link that has allowed with the connectivity wirelessly and ubiquitously, it is possible to raise indicators related to the use and e-learning of ICT (computer use, Internet access, e-mail and learning Web 2.0 tools). It is also necessary to move towards a new holistic vision of the initiatives, where the policies of technological diffusion by the government of Colombia, all of this can become more relevant and can form part of a broader strategy in which they are linked with policies of innovation, industrial policies, human resource training, IT training and promoting business applications.

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Games Math. Adaptive Video Game to Evaluate Basic Mathematic Concepts

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Abstract. Video games are interesting tools which can help teachers to motivate students so as to reinforce the main concepts related to Euclidean geometry, such as the types of angles, lines, and terms related with the circle and circumference. Currently, teachers are conscious about the low academic level of their students because they do not apply these concepts properly. In addition, it is observed that students show great affinity for the use of electronic applications, including online games and video games. This paper reviews the results obtained when using a video game to reinforce concepts related with Euclidean Geometry with students of the first academic level of Civil Engineering to which there were previously applied a traditional evaluation where they had to solve various exercises related to these concepts. After performing the activity raised in the online game called "Euclid: The Game'' there is carried out an evaluation of the student progress in the correct application of these concepts in practical exercises.

Keywords: Euclidean geometry · Video games · Basic mathematical concepts

1 Introduction

The main geometry concepts are indispensable for Civil Engineering students and a concern is being observed by the university teachers when it is evidenced that at pre-university and university level the students do not handle properly the concepts related to basic geometry.

The deficiencies that are evidenced among the students in the handling of this knowledge are due to that they do not understand them and/or they do not know how to apply them. For this reason, it is necessary to use different tools that allow not only to understand its application, but to evaluate the level of understanding of the basic concepts related to Euclidean geometry. To this end, it is proposed to use an online game as a classroom activity that allows the teacher to evaluate the students in the level of understanding these concepts, as use a striking visual environment.

The main difficulties that students face in studying the most relevant concepts of geometry are originated by the lack of memory to remember the formulas, the little spatial visualization and the incomprehension of the mathematical expressions since

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they do not deduce when and how they are applied. The structure of the document considered the theoretical foundation, the formulation of the problem and the objectives, the methodology, the data collection, the analysis and results, the conclusions and the future research and finally, the references.

2 Video Games for Educational Purposes

Video games are part of the daily life of students and although it is not very common its use as educational tools, it is undeniable that technological progress allows them to be part of the strategies available to the teachers to achieve the goals they have established in their academic work.

In order to foster the Proximal Development Zone proposed by Vygotsky (1987), the game takes on an important meaning as a didactic mean of learning as it facilitates getting out of boredom and anxiety and allows the person to immerse himself in an activity which is enjoyable for him. This condition is called Flow State, established by Csikszentmihalyi (2009), which is related to creativity, happiness and talent.

As one of the ways to play that is offered in the society is the use of video games, through them, the human being learns, assimilates, incorporates and innovates, allowing to transmit learning models to those who are beginning in life.

3 Formulation of the Problem and Objectives

A video game is defined as:

> An interactive computer program for entertainment which can work on various devices such as computers or game consoles. In turn, it integrates audio and video, which allows to enjoy experiences, scenarios or situations that, in many cases, would be very difficult to live.

In the revision of the educational possibilities of video games made by Pindado (2005), he mentions the works published by Mandinacht (1987), White (1984) and Okagaki and Frensch (1994) which show that video games favor the development of various intellectual abilities, such as attention, memory, problem solving, spatial concentration and even critical thinking.

Estallo Martí (1994), emphasizes that "video game players are usually subjects of higher intellectual level than their fellow non-players." That is, this tool can contribute so much to the emotional and intellectual development of the adolescent. The contributions made by Etxebarria (1998) are interesting because they indicate the educational possibilities that the use of video games has in relation to the school curriculum from the perspective of social learning theory, emphasizing the possibility of using this tool to treat student learning problems, since it facilitates a more effective training in aspects related to the psychomotor and deductive reasoning.

According to Koster (2004), it is fun to do these kinds of activities, since games are puzzles, where the brain is challenged to learn to analyze patterns. When a gamer (video game player) recreates himself with a video game, he does so until he masters the pattern. Video games are not only elements of entertainment, they also are tools that teach space relationships and explore or strengthen accuracy. They also have intellectual stimuli, which makes them very pleasant and satisfying. The motivation is stimulated or slowed depending on important factors that characterize it, such as the gameplay, the interface, the graphics and the type of game.

The engineer and mathematics professor, Jean-Baptiste Huynh (creator of the DragoBox work suite as appears in Siew et al. (2016)), believes that video games can be a powerful tool to support children's learning. They learn more easily when they perceive video games as something fun, entertaining, allowing them to experiment in a logical way and strengthening concepts, such as solving mathematical equations.

Currently Edutainment type video games are considered as games that try to be educational but are characterized by having little fun for gamers. It is believed that they are not appropriate to be employed in an educational environment because they are not attractive for those who will play them, due to the lack of interest or because they do not generate the same motivation as other video games.

As it appears in Pindado (2005), Group F9 stated in its article "Eight didactic proposals" the use of this amount of entertainment video games that allow to consolidate concepts related to several school courses, some examples are PC Futbol and Lemmings for mathematical contents.

Other games used are called "Serious Games" which have as objective to use the ludic technologies for pedagogical and formative purposes, being able to be adapted to the needs of the students.

One of the advantages of using video games is that they indicate the final goal in the form of a mission to achieve, where most of the time, the protagonist is the one who has to reach it. This allows the player to feel identified with what is done in the game, increasing the motivation to implement this strategy.

Sánchez León and Aguilar Gonzales (2015), has established the creation of an Evaluative Learning Object (ELO), using a video game, which is intended to evaluate and develop skills such as memory stimulation. The results show that combining multimedia elements reinforces the knowledge and helps control concentration on the evaluation of a concept, awakening the happiness and enthusiasm of students. It also showed that the use of video games allows better capturing and sustaining student's attention.

4 Euclid: The Game

"Euclid: The Game" (http://euclidthegame.com) is an online game inspired by the principles of Euclidean geometry, which was created by Kasper Peulen, using Java and the Geogebra package. This student of the University of Amsterdam designed this game where the students have to construct in such a way that is fun to overcome each level, using the tools that the application allows to use, strengthening the reasoning abilities in the geometry. It is an entertaining way of reinforcing the main concepts related to geometry, applying the five postulates of the elements that Euclid generated for the Euclid geometry.

The game invites the gamer to overcome 25 levels or puzzles, using several tools that allow to join points, build segments of lines or circles so as to score points. All this is to construct different geometric objects, such as equilateral triangles, parallel lines, perpendicular lines and circumferences, among others.

To reach the higher levels of this game it is only necessary to review the knowledge related to Euclidean geometry. The use of this game allows to introduce the student to the use of geometry tools, such as rule and compass, so that he can solve the problems that each level offers, applying concepts related to distances, lines, center of a circumference, etc.

As for the score that can get a player, this is granted depending on how efficient it has been in solving each puzzle. The number given by each level is related to the number of operations used to solve it. There are two types of medals, the silver medal is obtained when a level is completed satisfactorily and the gold medal which is awarded when a level is completed with a minimal amount of movement. As the levels are exceeded, it is more difficult to obtain this precious gold.

5 Objective and Methodology

The general objective of this research is to evaluate students' academic performance when using "Euclid: The Game" as an academic activity related to the concepts of Euclidean geometry and to compare the results obtained with the traditional methodology.

This project was carried out on a sample of 49 students of Civil Engineering program with the following characteristics:

- Ages: between 15 and 34.
- Timetable of the alums: The main majority of the students has a daytime timetable.
- Type of student's school: our students are in same percentage from public and private school.
- Year of discharge from secondary school: Much of the students ended the secondary education between 2015 and 2017.

To carry out the activity in the classroom, there were established the following phases:

- The Phase 1 was related with the basic research work in which documentary sources of specialized literature on the state of the art on aspects related to the project are reviewed. The main aspects considered where learning and motivation, mathematics and geometry, video games and its main features and the feasibility of its use to strengthen the notions of geometry (perimeter and area).
- The Phase 2 was based on the selection of the video game to be used in the project.
- The Phase 3 was the first evaluation of the geometry concepts.
- The Phase 4 was the application of the video game "Euclid: The Game" and on the collection of data required in this project.
- The Phase 5 was an evaluation after the application of online game (traditional type) on the concepts of geometry to the population under study. It consisted on 27 exercises related to concepts of circumference, types of angles and lines comparison.

- The Phase 6 was the analysis of the results obtained (evaluation: 0–5, game level: 1–25).

6 Results

6.1 Results of the Previous Test

The results obtained by the students in the previous evaluation appear in Table 1 and in Fig. 1.

Table 1. Results of the previous test.

Mean		3,896
Median		3,889
Mode		4,4
Minimum		2,2
Maximum		5,0
Sum		190,9
Percentiles	25	3,519
	75	4,444

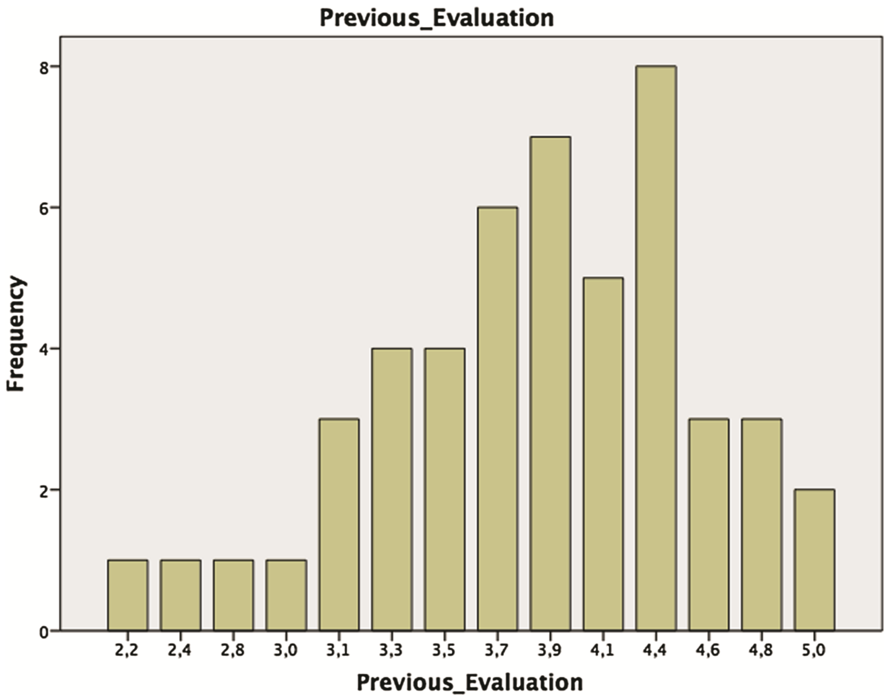

Fig. 1. Frequency of the of the results obtained in the previous result

It is easy to see that although there exist some bad and low results the clear majority of the results are in a medium-high rank of note.

6.2 Results of the Final Test

The results obtained by the students in the previous evaluation can be seen in Table 2 and in Fig. 2.

Table 2. Results of the final evaluation.

Mean		4,191
Median		4,259
Mode		4,1
Minimum		2,0
Maximum		5,0
Sum		205,4
Percentiles	25	3,796
	75	4,630

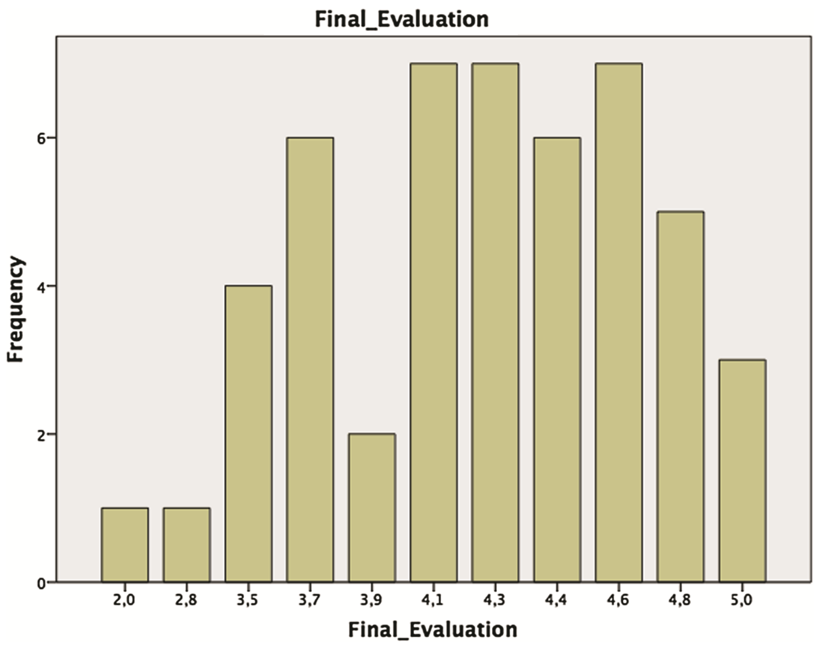

Fig. 2. Frequency of the of the results obtained in the final evaluation.

It is easy to see that the results seem better since the mean is greater and the higher results are greater. Moreover, we see that the sum of the results is greater in almost 15 points.

6.3 Results of the Game Level

The results obtained by the students in the previous evaluation can be seen in Table 3 and in Fig. 3.

Table 3. Results of the game level.

Mean		12,204
Median		13,000
Mode		15,0
Minimum		3,0
Maximum		25,0
Sum		598,0
Percentiles	25	8,000
	75	15,500

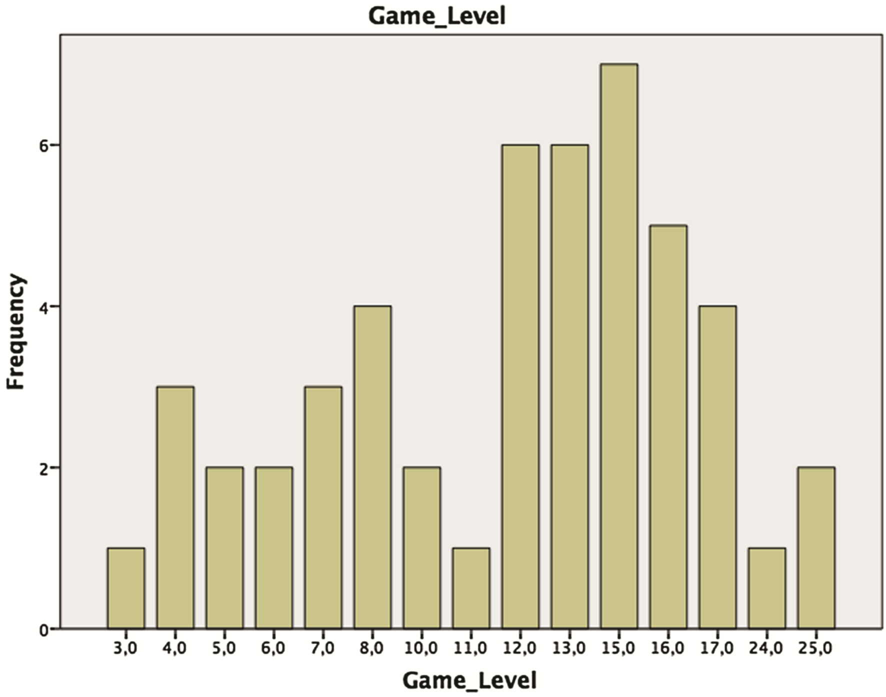

Fig. 3. Frequency game level raised by the alums.

We see that the level reached by the alums is high since the level obtained by most students is greater than 12.

6.4 Correlations Between the Game Level and the Final Evaluation Result

The correlations between the game level reached and the final evaluation result can be seen in Table 4.

Table 4. Correlation data

Correlations			
		Final_Evaluation	Game_Level
Final_Evaluation	Pearson Correlation	1	,715**
	Sig. (2-tailed)		,000
	N	49	49
Game_Level	Pearson Correlation	,715**	1
	Sig. (2-tailed)	,000	
	N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

We obtain that that there exists a significant correlation of 0.715 between the game level reached by the students and their final evaluations result.

7 Conclusions and Future Research

The conclusions of this study are clear since we have detected that the level of the Euclid game get by the students is directly related to the results in its final evaluation. Moreover, this correlation is significant.

Related to the future research we have different branches:

- Study the efficiency of the game by means of using a pretest-posttest evaluation.
- Compare the results by means of using a control and experimental group.
- Study the correlations between the initial evaluations and the level reached in the game.
- Develop a new methodology using the game and prove it with different groups and universities.

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Holographic Tools for Science Learning

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Abstract. The purpose of the present work is the design of a technological tool that improves meaningful learning in the teaching of science subjects. For this, a sample of 6th and 7th grade students from the educational institution "Vida para Todos", located in the Caicedo neighborhood of the city of Medellín (Colombia), were chosen and the contents of science were firstly worked in a traditional way and then with the use of holograms. It includes a series of activities designed for students to reach the concept of hologram and others for the assimilation of science contents. The evaluation of the tool in order to verify its effectiveness was also carried out.

Keywords: Significant learning · Science contents · Hologram

1 Introduction

The importance of science in society requires that teaching methods used in classrooms encourage meaningful learning based on competency achievement. For this reason, science subjects require to be taught in such a way that students understand them and arouse their interest in understanding the phenomena contemplated in the world around us.

Although the world in which we move is full of mathematical concepts, it is a fact that when teachers try to explain them in classrooms students are in great difficulties due to the fact that they are difficult to explain, they are not visible to the eyes, that is to say, they harbor abstract concepts, or to the curricular demands themselves, which means that sometimes it is not possible to devote more time to approach alternative methodologies to the traditional one.

Books explain with words and images contents that in most of the times are not understood because they are shown in a different reference point that does not allow the student to imagine and to understand the concepts clearly. All of the above can be understood as the principle of modality and redundancy that states that students learn best with animations.

According to the basic standards set by the Colombian Ministry of National Education (MEN), young people are encouraged to learn contents of a scientific and global nature that allow instruction and training in skills.

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According to the above, in MEN standards there are a series of items that allow students to develop, from the beginning of their school life, scientific abilities to explore facts and phenomena, analyse problems, organize, collect relevant information, use an evaluate analytical methods and share of information. It is also contemplated that the students can establish relations between the macroscopic characteristics of matter, as well as the physical forms and characteristics of the elements that make up our surrounding universe.

On the other hand, the knowledge society in the educational field, demands a complete digital re-literacy. Enhancing digital competencies is fundamental for the intervention of access to information and knowledge. Students are used to deal with technological devices, they are Digital Natives, and simple tools are no longer of their interest.

Based on this, the STEM pedagogical methodology (Science, Technology, Engineering and Mathematics) that intends to approach the interdisciplinary learning based on the resolution of projects, is crucial in the classrooms. This type of methodology brings important benefits when carried out in an appropriate way since it allows transferring the knowledge and skills of the student to the real world, conferring significant learning in which motivation plays a very important role.

2 Holographic Fundamentals

The human being has always shown his concern to represent the three dimensions. From the most primitive representations a clear evolution is seen that incorporates different techniques to produce the sensation of relief and depth, trying to achieve a certain depth of signals captured by the human eye. One of the techniques to reproduce the three dimensions that provide a sense of reality similar to the one we perceive with our eyes when we look at reality is the hologram.

The hologram was invented in 1947 by Dennis Gabor, who won the Nobel Prize for Physics in 1971. The idea consists of a three-dimensional photograph executed with a laser beam through an object so that a second ray is projected onto the reflection of the first one light, allowing to obtain three-dimensional optical images.

It can be explained that although this technique is not new, the illusory effect that it transmits has become very popular. It has filled the imagination of both entrepreneurs, scientists, writers and science fiction filmmakers in the possible uses that in the near future can be given to this technology. Recent advances in optics will allow this dream to become a reality.

Currently engineers are working in the field of holographic projection, although this still has many technological improvements to give, as the image processing is expensive and the information required to make an image is quite complex. There are different types of holograms, the interactive ones simulate with a high degree of realism the real object, but to try to achieve them requires a great technological advance, so in the present work it has been tried make a real approximation with the holographic illusions that are currently managed.

There have been advances in the holographic projection related to the visual improvement of the technique “Ghost Pepper” that was applied in the mid-nineteenth century. Nowadays, this technique is applied with improvements in the projection of image quality and binocular vision, which makes it an animated hologram almost similar to the original.

In the technique "Ghost Pepper", the viewer is in the main room but he cannot see a compartment hidden under the stage, in that place is where the actor is located, on top of him, there is a glass or reflecting surface that shows the floating and "ghostly" figure of the actor. As a result of receiving the light that impacts on it and reflects on the surface located on the stage, the room where the person or object is located to be projected should be dark, preferably black to highlight luminous colors on the reflecting surface.

Prisms are also based on the same technique "Ghost Pepper", with the difference that just a reflective surface is placed on top of a monitor or screen, the image is seen on the surface and the animated video must have black background colour so that the image is projected and appears floating.

3 Educational Applications of Holography

Technology advances exponentially and acquires new educational applications, reinterpreting and giving a new meaning to the learning process. In this context, the potential of the hologram in training programs is undeniable, especially in sciences subjects.

To consider the hologram as a means of teaching, it is necessary to define in advance what is understood through mean of teaching. Cubero (1997) defines it as a "material component of the educational teaching process with which students perform specific actions aimed at the acquisition of knowledge and skills."

Serra et al. (2009) establishes a pedagogical foundation of how the hologram is a teaching medium considering how the principles of general pedagogy support it.

Hologram is itself a stimulus and a detonator of the motivational aspects for its value of innovation, and has a high significance in the meaningful construction of knowledge. The construction of knowledge is strengthened and increases its effectiveness as that knowledge is more applicable and contrasted.

The fact of being able to observe an image in three dimensions is motivating in itself. The student has the feeling that this object is present and feels more predisposed towards learning.

There are three factors that allow us to argue this fact:

- The possibility that this observation facilitates mental representation and the formation of concepts, laws, etc.
- It allows to obtain the representations based on the relations between the form and the content.
- It strengthens the relations between the students due to the fact that new conceptual relations both of individual character and with the whole class group are originated.

Likewise, its motivational potential is projected in the possibility of generating learning contexts among equals that allow the creation of a shared work environment (Pozo and Monereo 2009).

Therefore, we understand that the hologram constitutes one of the most iconic visual reproductions of the existing ones, which is its main quality in its use as a means of teaching. Through the hologram it becomes easier to understand science phenomena.

Taking into account that the design of the technological tools needs to be in accordance with the contents that are wanted to be explained, and that this must take precedence over the actual use of the technology itself, studies carried out by Kerawalla et al. (2006) show that the use of technological tools may favor a decrease in the dialogue between students if they are not an adequate use of them, that is, if it use is limited to a means of visualization.

For this reason, it is crucial the training of teachers in the use of new technologies to encourage to achieve meaningful learning while fostering collaborative work for the integral training of the student.

The idea of creating an interactive hologram for teaching science or other subjects was inspired by the following research papers using similar principles of holographic interaction for topics such as biology. Balogh et al. (2006) made a project in which they used different optical modules that sent light to a holographic display to show a hologram without the need of additional use of lenses. Agócs et al. (2006), collaborator of the previous ones, used diverse optical modules besides mirrors to obtain certain interactivity.

From the studies of Balogh et al. (2006) in the South California University Technological Institute, Jones et al. (2007) developed a device composed of a field light visualizer that allows human binocular eyesight to be able to see an image formed in 360°. This is possible thanks to a high-speed projector which transmits images to a mirror with a holographic diffuser and electronic circuitry to decode digital video signals. This shows a projection of the object which can be observed without the need to wear special lenses and it avoids the restriction of seeing yourself only from a reference point.

Ghuloum (2010) carried out a study on the effectiveness of the use of holograms in education with 400 teachers. The results showed that teachers considered this technique potentially effective in achieving meaningful learning.

Finally Kim (2014) wrote an informative article that shows all the projection techniques that are currently used, in addition to the prisms and the holographic projection that was used in this work for the interactive contents of high school students.

It should be noted that the research works that mention the use of holograms for educational purposes, derived from the collections of Serra et al. (2009), as well as the thesis work of Magister de Porras (2014), are based on analog or transmission holograms which are in static plates and are not in motion. It deals with interactive holographic applications through posterior projection or mobile prisms whose objective is to create interactive contents for people of both commercial and institutional applications. For this work we will apply holograms it in educational field with high school students of high school sixth and seventh grades of an official educational institution of the city of Medellín.

Lee (2013) establishes a series of challenges with which the holograms have to face. Firstly it speaks of the representation of the images since many of the applications used do not offer the sufficient quality. Likewise, he says that prolonged use in the classes of these technology can have negative repercussions at the visual level and loss of consciousness, meaning that for students with vision or neurological problems is not very suitable to use this type of tool in a prolonged way. The solution proposed in this article is the use of an interface that allows the interaction with the hologram either through a speech recognition system or a neurological device that converts brain signals into commands that control the interface.

4 Objectives and Methodology

The general objective of the present work is to design a holographic technological tool that contributes to the meaningful learning of the students of the 6th and 7th grades of the high shool in the area of the sciences, also helping the teachers in their way of teaching interactive pedagogical contents, following the principles of modality and redundancy.

For this aim the following specific objectives have been proposed:

- Motivate students to create holographic prisms to understand the concept of a hologram and observe its characteristics.
- Develop an interactive application, which will be projected holographically to show students the application of the concepts of science topics.
- To verify through surveys that holographic technology is so effective and if it exceeds the teaching of educational content with respect to traditional methods.

4.1 Sample

For the design of the activities, the 6th and 7th grades were taken as the sample, which were the groups 6 ° 1, 6 ° 2, 7 ° 2, 7 ° 4 and 7 ° 5 respectively, in order to obtain a sample of individuals that validated the use of the technological tool as a means to verify the veracity of the principles of modality and redundancy, and corroborate that complex concepts are learned in a clear and entertaining way.

4.2 Method

To carry out the classroom work a series of steps were established:

- A session in which materials are requested for the construction of home prisms and an initial survey on traditional contents is solved in order to contrast their opinions on how to teach traditional contents.
- A session in which the prisms are assembled and a survey on the operation of the prisms is answered. This is intended for students to understand what a hologram is and how holographic contents are viewed through prisms.
- A session where the prisms are used and another survey is carried out on the holograms, their advantages and characteristics. The aim is to verify if the students have understood the uses of different prisms to watch videos and different kinds of holograms.
- In the final session an interactive hologram is made with an application already made. The students interact with the device and then carry out a final survey on the holographic contents, subsequently verify the results of the various surveys and draw the respective conclusions.

During these sessions evidences were collected such as interviews, photos and videos of the applications to leave them as concrete evidence on the web. For the development of the didactic unit, the student interacts with a large holographic projection, which was done by means of a assembly in the classroom, later a sensor is programmed so that the student can interact with it and evaluate what he have learnt from his experience.

For the work with the prisms there were used devices that show holographic videos, from a prism of simple angle (at 45º), only seen in a single direction, to the pyramidal prism that can show a figure in 360º and a Multi-plane prism (i3DG) where there can be seen various backgrounds or layers to give an even greater 3D effect. The prisms have been made with music CD boxes, using different measures according to the size of the hologram to create, a prism for cellphone or a prism for computer screen. Figure 1 shows the result of the projection with a pyramidal prism made by students in the classroom following the teacher's instructions.

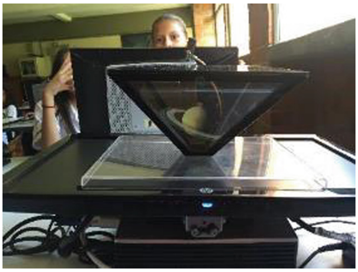

Fig. 1. Pyramidal prism.

In addition to the prisms two types of assemblies were made, one is "Ghost Pepper" and the other is a similar projection with the difference that a mirror is placed to amplify the projected image, the latter one is called "Rear Projection". For the first they were required an acetate and a projector that impacts a mirror that sends the image to a reflecting surface that finally shows its reflection in the acetate and it is seen as a holographic illusion, then it is placed an interface of interaction where the student can watch the contents of the projection (In Fig. 2).

Fig. 2. Ghost pepper tecnique

The second projection (Rear projection), is constructed by means of the use of a semi-transparent sheet that functions as a screen and a projector and points to a mirror in the back part. This projection sends the amplified image to the cloth that reflects it and gives it the appearance of holographic illusion similar to the "Ghost Pepper". It differs in that the surface is not completely transparent and in the way of projecting the images (Fig. 3).

Fig. 3. Rear projection.

By means of a sensor of remote movement, the student interacts with the content as it detects its movements. The sensor that has been installed is Kinect, given its characteristics of motion detection at some distance and interoperability with the Windows system, which is an accessory of the Xbox video game console. This sensor requires an adapter that connects to a USB port, since the connector of the sensor is not compatible with the ports of the computer.

The program thinglink was used to design the applications related to the contents to study in order to verify effectiveness in the learning acquired through this tool. Thinglink is program easy-to implement and to upload in the web that does not require a lot of resources.

In order to approach the application of this tool two contents were taken, on the one hand we worked the thematic of the solar system which includes the planets that compose it and the characteristics of each one. In the application there were placed the sun and the planets each one with an icon so that when placing the sensor deploys an animation of the respective planet turning and with the relevant information as the size and quantity of satellites that owns.

In the second example the theme of fractals was used in objects of nature and geometry, this was done with the purpose of comparing the fractal figures with the elements seen in the area of sciences such as biology and chemistry, according to the achievements pose for 6th and 7th grades.

In order to obtain the information required for this project, surveys on how natural science is being taught and the degree of satisfaction after the implementation of the didactic unit and the innovative tool used were carried out. In addition, a video of the theme was put up in a group forum made up of teachers on the social network Facebook, to see the opinions of other educators who carry out the same educational work about the use and benefits of the technological tool.

Photographs and videos of the activities done by students to reach meaningful learning through the didactic unit were recorded and it was carried out an interview in which some students gave their video testimony of the experience acquired with the tool used and their opinions regarding the advantages and benefits of the use of the tool compared to the traditional methodologye 1.

5 Results

In order to evaluate the use of the holographic tool in the first place and before working with this tool, it was considered important to assess the students' opinions on traditional tools such as textbooks. The results showed that 52.1% of the students considered that these tools should be more entertaining for learning, 20.4% considered that they should be more graphic, 16.9% that should draw more attention and the remaining 10.6% that should not be so tedious.

Subsequently a survey was made to know what the students understood by the term hologram. The results showed that 48.9% of the students considered a hologram to be a mirage, 38.9% that it is a virtual representation of a real object, 10.9% as an illusion and the remaining 2.2% as a game.

When showing them the prism assembly, the 73% said that it was a home prism, 21.3% a mobile device, 4.6% that was a video game and 1.1% a binocular.

Once the holograms were worked, the students were asked about the usefulness of the prism and 83.9% answered that their use is to watch holographic videos.

Related to the holographic contents for the learning of the sciences, the opinion of the students regarding the use of the interactive tools was valued. The results showed that 81.2% of the students considered that they are very useful to work the contents of sciences. In addition, 70.9% considered that holograms help to understand the contents of science better due to the fact that its movement in three dimensions draws more attention and 82.5% considered they would learn much more if the contents were worked with the use of holograms.

To evaluate the results related to the intervention in the forum of Facebook, a video was posted in the group forum "Teachers Decree 1278" and teachers were asked to give their opinion. The number of likes was 85 and all teachers showed great interest in knowing how the tool was developed.

6 Conclusions and Future Research

The surveys carried out, the work aimed and the evidence described give an idea of the great potential of the hologram in the near future, once progress is made in projecting the figures in volumetric screens and the contents are coupled to the projections.

At the moment the contents are limited to 3D designs and can be seen in prisms and in assemblies that give the illusory sense of hologram with limitations related to the parallax barrier, difference in perspective of an object when viewed from two Different points, and angular perspective.

The binocular perspective and realism that provides the contents in this class of visualizations, establishes to the hologram like a unique projection in its type, since it shows multiple views to the observer with respect to an object. This makes possible that abstract contents, are more understandable once viewed by this method, as they can change their perspective on different planes with respect to a content, that is, the observer can look at an example of a particular object and if he suddenly does not understand from a specific visual position, by simply just changing the place he could be able to look at the content in other position.

This makes it possible for the contents intended to be displayed in holograms to have an endless number of uses in almost all fields, adding interactivity, it makes possible for people to become involved in the contents, strengthening their use.

Although the student does not understand the concept of how a holographic illusion works since his knowledge of the physical behaviour of light is limited, in synthesis what is expected of him is that he has knowledge of what a hologram is in physical reality, and what represents for him in terms of the visual part and understanding of scientific concepts, facilitating his learning from the point of view of the theory of the principles of modality and redundancy.

From the point of view of the expected achievements in learning, it was verified with the sample of the groups of high school that the students tend to pay more attention when the ideas appear in an animated form than in static form. Although this work emphasizes the holograms with movement, in the work of Porras (2014) it is evident in the functionality and multiple applications of the static holograms in what these can achieve in terms of the significant learning of the student, which agrees with the article of Serra et al. (2009), in which he mentions the benefits of the hologram from a pedagogical perspective as a tool and motivating entity in the learning process.

Reaffirming this point, it is mentioned the science project of the university EAFIT realized by Velásquez (2014) which shows the scope and interest that this innovative tool can demonstrate to the young people through the teaching process. With all this information it can be inferred that there is enough solid evidence for the use of holograms in educational contexts based not only on the result of this report, but also of other authors that corroborate this fact.

It was possible to establish with the different modes of projections in holograms, that the learners felt more motivated when interacting with the animated digital contents, since they are not static like the images of the books and magazines, although it is not discarded the interest in the use of traditional means. The activities not only tested the principles of modality and redundancy, but raise the holograms as an educational element to take into account in the institutions in the future.

Although the results provided in the surveys were taken from a small sample, and several sessions were held to validate the use of this technological innovation, it is predictable that the holographic projections will soon take place in our academic and urban environment.

The results obtained with the diagnostic elements used in this work, together with the opinions of the students in the interviews and the classroom sessions, in addition to the interventions of the teachers in the forum raised in the social network Facebook, so that the holographic projections may have diverse uses and that can extrapolate from the academic context, that not only serve to teach science subjects but other subjects. The report made by Serra et al. (2009) used diagnostic means similar to this work, whose result was positive in the didactics that holograms can have in learning physics, evaluating its high influence as a pedagogical element.

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Learning Tools and Environment

Disruptive Educational Environments – What Guides Teachers?

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Abstract. In recent years, many schools have had ‘bring your own device’ and ‘blended e-learning’ initiatives that have created a need for knowledge about the affordances of digital tools and online platforms in 1:1 environments, where each student has access to a digital device to support learning. This paper examines this need among teachers at upper secondary educational schools. The research question is: How do innovative teachers manage to exploit technological affordances and create educational added value? The paper provide research evidence suggesting that these teachers create educational added value in 1:1 classrooms, since they regularly provide immediate, task relevant and formative feedback to the students and address their perceived self-efficacy.

Keywords: Blended e-learning · 1:1 educational settings · Technological affordance · Learning analytics · Perceived self-efficacy

1 Introduction

Since the millennium, there has been a fundamental change in educational settings in several countries including Denmark. Within a few years, the principles of ‘bring your own device’ (BYOD) and ‘blended e-learning’ have disrupted the educational settings. As a result, schools transform into 1:1 environments where teachers and students habitually access materials on the web and frequently use digital tools for dialogue and cooperation.

This disruption is intentional, but it is seldom initiated by school staff. The main driver is the rationale for using educational technology represented by politicians and decision makers. Often, wide-ranging visions generate a blind spot regarding the deeper dimension of transformational change [20]. More specifically, it creates a discrepancy between the overarching visions on the one hand and the teachers’ capacity to implement these visions on the other hand [8].

Although the principles of BYOD and blended e-learning are not very far from the customary visions of secondary education, it is an open question how teachers should transform them into action. Even when a digital vision is explicit, questions still remain regarding how it should be implemented; for example, these issues include the digital technology to be used, and why and how to use it.

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2 Research Objectives

So far, there has been little research on the ways in which early adopters among the teachers provide sustainable answers to these questions. This paper investigates innovative teachers' efforts to integrate the technology into their teaching at upper secondary schools in Denmark, which is the first country in the world to implement 1:1 classrooms in all public schools [22].

I also examine how the principles of BOYD and blended e-learning provide new opportunities for teachers to enhance students' learning processes and acquire knowledge about their motivation for learning. In particular, I examine the technological affordances of digital tools and online platforms from the point of view of early adopters. The term 'technological affordances' refers to functional aspects that frame but do not determine the users' action in relation to the digital technology [13].

The research question is: How do innovative teachers manage to exploit technological affordances to create educational added value in 1:1 classrooms?

3 Related Work

Since the mid-1980s, findings from research on 'the reflective practitioner' have been an integral part of teacher professional development in Denmark [14]. Often, teachers reflect during and immediately after learning events. Some scientific studies in this are focus on the timing of reflections and distinguish between reflection *in* action, which takes place during practice, and reflection *on* action that takes place after practice [21].

When teachers plan new actions, they can build on reflection on action and continuously improve these actions. The disruption of educational settings related to BYOD and blended e-learning initiatives, however, challenges this approach, since knowledge about previously completed actions is not enough for innovative 'first movers' in 1:1 educational settings. Innovation refers to events where people form an idea that is perceived as new and put it into practice [19]. To decide how and whether such pedagogical ideas support or expand learning, these ideas have to be accompanied by experiments, i.e., teachers have to experiment with teaching in connection with blended e-learning and the use of digital tools and online platforms in 1:1 classrooms.

There is research evidence suggesting that students' learning outcome is highly influenced by explicit teaching including lectures, guidance of problem solving activities and demonstration of learning tools/materials [11]. For example, the effect size of 'direct instruction' is 0.59 and thus above the average effect size of 0.40 [12]. Consequently, teachers need to acquire knowledge about teaching in connection with implementation of the BYOD principle and blended e-learning. In particular, they can obtain such knowledge about technological affordances through reflection on experiments with digital tools, online platforms and educational apps.

There is also research evidence suggesting that teachers' knowledge and provision of clear expectations highly influence student learning outcomes. For example, the effect size of 'teacher clarity' is 0.75 [12]. Moreover, there is research evidence suggesting that students' self-regulation of motivation and behaviors depends on goal systems and outcome expectations [5]. When the teachers regularly provide learning objectives and other outcome expectations on-line, the students can check them whenever they need it – and in this way increase their time on task.

Clear expectations are important whenever the students engage in self-directed activities in 1:1 classrooms and when the students engage in blended e-learning activities. There is research evidence suggesting that blended e-learning has a higher impact on students' learning outcome than pure f2f-education or pure online learning. This lead of blended e-learning relates, among other things, to increased time on task. The effect size of increased time on task is 0.46, while the similar effect-size of increased time on task on students' learning outcome in pure f2f-education is just 0.38 [15].

4 Research Methodology

This paper presents research findings from an empirical study concerning teachers in upper secondary education. A rather small number of teachers were invited to participate in the research, but they represent the early adopters in 1:1 environments in youth education, and they all participated in a development project funded by The Central Jutland Region in Denmark.

The study was based on a mixed-methods research design. Firstly, data was generated through focus group interviews with the digital innovative teachers. Afterwards the interviews were transcribed and analyzed based on an open coding strategy according to the approach to qualitative data analyses called *Grounded Theory*.

Secondly, data about the teachers' experiences were generated by means of a questionnaire. The questions had a common introduction: "The use of ICT affects your opportunities to strengthen students' academic achievement. To what extent do you do the following:" This part of the questionnaire was followed by descriptions of different types of teacher activities, e.g., "Engaged in formative assessments of students' performance?" and "Assessing students' understanding of the learning content?" In total, 64 teachers from twelve general and vocational upper secondary schools participated in the survey, which corresponds to a response rate of 93 pct.

Thirdly, I collected survey data from students at eight general and vocational, upper secondary schools in the previously mentioned region. They answered questions about the perceived help from their teacher in the 1:1 learning spaces. These questions had a common introduction: "When working with ICT in education, to what extent do your teachers help you:" It was followed by descriptions of different types of teacher activities, e.g., "Providing feedback on your writing assignments?" and "Understanding the requirements of your tasks?" A total of 446 students from 25 classes participated in the survey, which corresponds to a response rate of 76 pct. The classes were chosen by the teachers participating in the survey. At four of the twelve schools involved, the students were in enterprises at the time of the survey, so the classes were affiliated with eight of the schools.

In survey, teachers and students responded by entering a number between 1 (representing 'not at all') and 9 (representing 'very much'). On this scale, answers equal to or higher than '5' represent a rather positive experience: the teachers strengthen the students' learning opportunities from 'in some degree' to 'very much'. Descriptive statistical results were subsequently generated by means of the digital system used in the survey.

5 Research Findings

The focus group interviews indicate that the teachers are guided by scientific knowledge about formative feedback [1]. In particular, they are informed by research evidence suggesting that provision of formative feedback in general fosters students' learning processes as well as teachers' knowledge about these processes [2]. In general, they do not have enough time, however, to study the results of research and development projects. Therefore, they form relevant and prosperous ideas regarding technological affordances from other sources including their colleagues and digital technology supervisors and headteachers at their schools. For example, teachers often experiment with digital sharing tools and interactive materials and exchange their experiences with their colleagues.

Due to these experiments, collegial support and in-service teacher education programs in Denmark, teachers were capable of applying digital technology into their 1:1 classrooms. In general, they, however, want more guidance in this area. In particular, they are anxious to learn about how and when technologies support and extend learning (ibid.).

A few teachers reported that their students in upper secondary education had to learn to use some online platforms, but in general the students were able to exploit the digital technologies for their learning purposes. This observation is in line with the national objectives according to which Danish students should be able to use digital tools and online platforms to search, collect and analyze information as well as to show safe and responsible digital behavior knowing the consequences of their digital footprints on the internet [23].

Regarding computer and information literacy, the students (8^{th} grade) in Denmark develop some of the highest computer and information competences in the world [9]. In addition, the percentage of students (7^{th} grade) with three or more computers at home is also higher than in other countries [16].

Table 1. Study with the participation of teachers at upper secondary schools. The higher the response value, the greater the effort, with 1 = "Not at all" and 9 = "very large extent".

The use of ICT affects your opportunities to strengthen students' academic achievement. To what extent do you do the following:	Average
Getting through to the most difficult students	6.2
Answering awkward questions from students	7.3
Providing an alternative explanation when students do not fully understand something	7.9

Consequently, the teachers can immediately take advantage of the flexible online communication about learning in 1:1 environments (Table 1).

Each of the responses shown in Table 1 is, of course, associated with some uncertainty. Regarding the confidence interval, the true value is with 95 pct. probability contained in a range that is the specified value ±0.2. The same applies to the following Tables 2, 3 and 4.

Teachers have to deal with the individual differences of the students, and it appears from the table that they often use digital dialogue to reach the most difficult students. Furthermore, they answer burdensome student questions and provide alternative explanations. The dialogues in the 1:1 environments help the teachers acquire an overview of the progression of learning and to enhance student learning. The availability of real-time insight into the performance of the students qualifies the teachers' judgement when they plan learning activities for diverse students. This includes their efforts towards students for whom they are not doing enough today or who are at-risk.

The teachers' formative evaluations of student work provide information about students' performance and understanding, and according to Table 2 the use of digital technology often affects the teachers' opportunities to strengthen students' academic achievement.

Table 2. Study with the participation of teachers at upper secondary schools. The higher the response value, the greater the effort, with 1 = "Not at all" and 9 = "very large extent".

The use of ICT affects your opportunities to strengthen students' academic achievement. To what extent do you do the following:	Average
Engaged in formative evaluation of students' performance	6.7
Evaluate students' understanding of the learning content	6.8

According to Table 3, teachers often strengthen the individual student's believes that he or she can cope with the school work. Regularly, the teachers enhance the students' perceived self-efficacy. The notion of 'self-efficacy' refers to students' beliefs about their capabilities to produce given attainments [4].

Table 3. Study with the participation of teachers at upper secondary schools. The higher the response value, the greater the effort, with 1 = "Not at all" and 9 = "very large extent".

The use of ICT affects your opportunities to strengthen students' academic achievement. To what extent do you do the following:	Average
Strengthening students' believes that they can cope well with school work	7.0
Strengthening students' expectations in education	6.7
Motivating students who show little interest in schoolwork	6.8
Strengthening students' industriousness in the school environment	7.1
Helping students to appreciate what they are learning	7.3

In particular, the students' motivation depends on their expectations for new learning activities and their appreciation of these activities [17]. It appears from Table 3 that the teachers make an effort in both areas. It is also clear that they often use on-line dialogue in order to enhance students' motivation and persistence.

The students generally appreciate that the teachers use online communication to enhance and evaluate their competence development. In particular, they appreciate that the teachers comment online on their work in progress (Table 4).

Table 4. Results of the student survey (Bjerringbro Gymnasium, Egaa Gymnasium, Lemvig Gymnasium, Viborg Gymnasium and HF, Knowledge Djurs, Social and health Horsens, Technical School Silkeborg, VUC Aarhus) (N = 446).

When working with ICT in education, to what extent do your teachers help you:	Average
Providing feedback on your writing assignments (e.g., via task facility on the school learning portal)?	6.1
Understanding the requirements of your tasks (e.g., if the student has misunderstood something)?	6.1
Solving tasks that you find it difficult to solve (e.g., by giving examples of solving opportunities)?	6.0
Evaluating your outcome of school work (e.g., via an electronic evaluation)?	5.5
Evaluating how well you understand what you need to learn (e.g., via an electronic evaluation)?	5.4

Additionally, the students appreciate that the teachers create clear and explicit expectations about the requirements of learning tasks and support them to solve their tasks when they find difficult to solve on their own (Table 4). Both Tables 2 and 4 show that students generally have positive experiences with immediate, task relevant and non-evaluative feedback.

6 Discussion

When students experience difficulty in 1:1 educational settings, teachers often provide process oriented feedback that not only provides correct answers, but also suggests how these answers could be derived. Such technological affordances can promote a shift in focus from summative to formative feedback. The innovative teachers tend to develop a formative feedback culture in the 1:1 classrooms.

Whenever they respond to questions and provide feedback, they gain an insight into the students' achievements and the progression of their learning. When they become aware of learning challenges and environmental impediments helping them to plan differentiated learning activities, they will be better able to answer questions like: 'What can the students do on their own, what are their individual challenges in education and what is needed to reduce these challenges?'

This is in line with related research findings. For example, two researchers observed nine teachers that were either relatively effective or ineffective in terms of student performance on mathematical skills test [11]. Teaching effectiveness (as operationally defined in the study) appeared to be strongly associated with, among other things: student initiated behavior; general clarity of instruction, and availability of information as needed by the students (process feedback in particular).

In addition to designing digital learning environments where students regularly receive oral feedback, the teachers can provide written feedback that is developmental and non-evaluative (ibid.). Previously, teachers often made manual records of the students' work [18], but whenever teachers evaluate the students' processes and products using e-learning platforms or digital sharing tools regularly the can avoid some paperwork, and the principles of BYOD and blended e-learning activities most often make it easier for the teachers to provide formative feedback.

There is research evidence suggesting that provision of formative feedback highly influence students' learning outcomes. Twenty years ago, Black & Wiliam [7] provided research evidence suggesting that formative feedback has a relatively high influence on student learning. Since then, other researchers have confirmed that the students most often learn from timely and constructive feedback if they reflect and use it during their learning [10].

Formative feedback is a theme in recent meta-analysis of learning outcomes. For instance, there is research evidence suggesting that the influence on these outcomes is 0.75 when the students receive effective formative feedback tailored to their level of mastery [12]. Moreover, the general effect size of formative evaluation is 0.9, which is also well above the average effect size (ibid.).

Such evaluations include the students' capabilities as well as their perceived self-efficacy in digital learning environments. Essentially, this self-efficacy depends on whether they expect to be able to cope with various learning tasks [5]. Figure 1, which illustrates the relationship between *formative evaluation* and *students' achievements* and *students' perceived self-efficacy*.

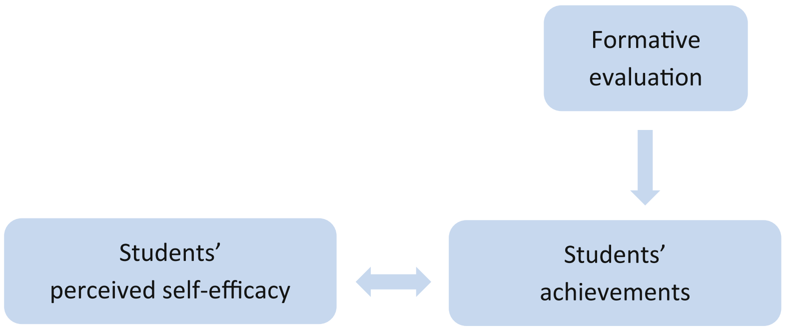

Fig. 1. Impact of formative feedback

When the teachers make formative evaluation, they obtain knowledge about the individual student's learning activities. By collecting, analyzing and discussing data on the students' challenges and self-efficacy, teachers are able to tailor their support and guidance to the needs of the individual student related to events in 1:1 contexts. In addition, they can directly or indirectly enhance students' self-efficacy.

There is research evidence suggesting that students' perception of upcoming tasks and judgment of their own capability to perform these tasks well is a highly influential factor in the self-regulation of motivation [5]. As a matter of fact, this factor is the most reliable indicator of their performance. In comparison with other factors, it is the one that correlates best with the learning outcome [6].

7 Conclusion

This paper deals with the disruption of youth education based on extensive BYOD and blended e-learning experiences. This disruption, which is mainly the result of current technological visions, creates some challenges for teachers, because their practices in flexible 1:1 environments diverge from prevailing practices. However, they do not diverge to the extent that the innovative teacher ceases to act as a driving force in the flexible 1:1 environment. In fact, this paper presents research findings suggesting that innovative teachers manage to exploit technological affordances to create educational added value.

The innovative teachers acquire knowledge about the technological affordances through numerous experiments with digital tools, platforms and learning materials in the 1:1 classrooms. I have examined these issues at upper secondary schools and documented that the innovative teachers manage to realize the potentials in the digital settings. In the 1:1 classrooms, the students, for example, appreciate that the teachers:

- Evaluate how well they understand what they need to learn
- Explore the requirements of their tasks
- Solve tasks that they find difficult to solve
- Evaluate their outcome of school work
- Provide feedback on their writing assignments

Teachers also qualify their professional judgement by means of educational research findings. They only rarely study scientific knowledge, but they form the relevant and prosperous ideas from other sources including their colleagues and headteachers. Such ideas, among other things, caused the teachers in upper secondary school to develop a feedback culture with lesser error correction and grading than before and more formative and differentiated support during learning activities. For example, they commonly:

- Assess students' understanding of the learning content and engage in formative assessment of their performance
- Answer awkward questions from students and provide an alternative explanation when they do not fully understand something
- Motivate students who show little interest in schoolwork and get through to the most difficult of them
- Formulate clear expectations and strengthen the students' believes that they can cope well with school work
- Help students appreciating what they learn and strengthen their industriousness in the school environment

Consequently, the ongoing online activities in 1:1 environments qualify the teachers' efforts towards students for whom they are not doing enough today or who are at-risk.

Moreover, the teachers at upper secondary schools develop a data culture where they usually act upon insight into digital environmental enablers and impediments, i.e. qualitative data from on-line interaction with students. Such formative interventions create a win-win situation, since they foster students' learning and also help the teachers gain an overview of students' challenges, which they can use afterwards to adjust their guidance.

In summary, innovative teachers' efforts in upper secondary education encompass technological experiments related to BOYD and blended e-learning. Based on reflections on experiments with digital technology in 1:1 classrooms, they develop knowledge of the educational affordance of these disruptions. This includes knowledge about the benefits of formative approaches to evaluation. In particular, it includes knowledge about the benefits of formative feedback in 1:1 classrooms. In general, the innovative teachers benefit from this knowledge and provide immediate, task relevant and formative feedback to the students, address perceived self-efficacy, and manage to exploit technological affordances to create educational added value in 1:1 classrooms.

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A GRADE Requirements Engineering Management Model Based on the Co-creation of Value

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Abstract. Effective design, organization and development of a complex information system that meets the need and value of the users are not trivial. It is important that the co-creation of value is involved in the requirements engineering management. This paper proposes a requirements engineering management model based on the co-creation of value for solving the challenges in the organization and development process of such projects. The paper begins with the design scheme of the Laboratory Intelligent Management System project in our University, Then, aiming at the challenges such as understaffing, personnel changes, requirements change, budget increase, user complaints, legacy systems and evaluation encountered during the organization and implementation process of it, a innovative GRADE requirements engineering management model based on the co-creation of value is proposed and explained by a case study. The paper concludes with suggestions for further design, organization and development of such systems with this model, and the prospect of applying the co-creation of value to the IT domain.

Keywords: Information system · Laboratory intelligent management system · Requirements engineering · Co-creation of value

1 Introduction

University laboratory experimental activities are integral part of engineering education and also an important base for developing students' creative spirit and practical ability. In order to improve the management efficiency of the laboratory, promote the laboratory opening hours, clarify the experiment contents, safeguard the safety of the laboratory operation and reduce the workload of the laboratory staff. Different high education organizations designed and developed their Laboratory Information System (IS)

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separately [1–4]. In 2011, A Laboratory Intelligent management system (LIMS) project was launched in our University. The project involves dozens of management and development team members, tens of millions of the capital inputs and hundreds of hardware. This project is implemented in three phases to reduce risk. The first 2 stages was finished in 2015 and the third stage is still in progress. A lot of meetings were launched and more than 30 higher education organizations visited it for the requirements, design, challenges, experience and lessons of the LIMS project. Through the project practice empiricism, internal exchanges and exchanges with people outside our University, we find that effective organization, design and development of the LIMS project that meets the need and value of the users in our University are not trivial. The project encounter understaffing, personnel change, requirements change, budget increase, user dissatisfaction, legacy systems and other challenges. These challenges are also likely to be met and cared for by other higher education organizations. It's important to do research on the challenges, experience and lessons in this project. The research result will be helpful for the following development of the project in our University and are also useful for similar projects, especially for those LIMS projects used for all schools of a Higher Education organization.

It is well known that effective and efficient requirements engineering (RE) activities are absolutely essential if software systems are to meet the expectations of their customers and users, and are to be delivered on time and within budget [5]. Capturing the requirements is a critical aspect of all system design if we want the system to meet the needs and value of the users. Many systems failed because there was a lack of correct method to capture the needs of the users. It is important that we not only capture the needs of users, but their values too. In the business realm, the co-creation of value models and procedures is used for user value research. Ideally, it can be used in RE to capture the user value.

This paper tries to explore how to use the co-creation of value in RE to effectively exploit user value and develop better software system.

The paper begins with a brief review of the design and challenges encountered in the LIMS project in our University, and then presents a simple and easy to remember GRADE RE management model based on co-creation of value. The next session describes a case study showing how to deal with these challenges with the GRADE model, and discusses the importance of why co-creation of value has important implications for effective design of the LIMS. The paper concludes with suggestions for further design, organization and development with the GRADE model.

2 The Design and Challenges of the LIMS

There are 12 Schools in our University. Each School has several laboratories. Each laboratory can provide facilities for many courses in the form of experimental activities. The same course may use more than one laboratory. In order to improve the management efficiency of the laboratory, promote the laboratory opening hours, clarify the experiment contents, safeguard the safety of the laboratory operation and reduce the workload of the laboratory staff. Before 2001, the school of Materials Science and Engineering (SoMSE), the school of Computer Science and Technology (SoCST), the school of Chemistry, Chemical Engineering and Biotechnology (SoCCEB) developed different systems such as Laboratory Reservation System (LRS), Experimental Contents Management System (ECMS) and Internet of Things Middleware System (IoTMS). The LRS provides users with intuitive laboratory reservation status presentation and interaction. The ECMS is used to display professional experimental system and manage experimental contents. IoTMS is used for remote real-time monitoring and management laboratories through door controllers, intelligent power supply controllers and monitoring systems. In 2011, a LIMS used to manage all 12 schools of our University had been designed [1], which is a super set of the LRS, ECMS and LIMS.

2.1 The Design of the LIMS

The LIMS is divided into Campus Network, University-level and School-level. The designed architecture of the LIMS in our University is shown as Fig. 1.

Campus Network is maintained by Information Center of our University. It supplies Application Programming Interfaces (APIs) of Central Authentication Service (CAS) and University Shared Database to the LIMS.

University-Level Platform, the laboratory portal of whole University, is a software system deployed in the Data Center of our University, and is used to present the basic

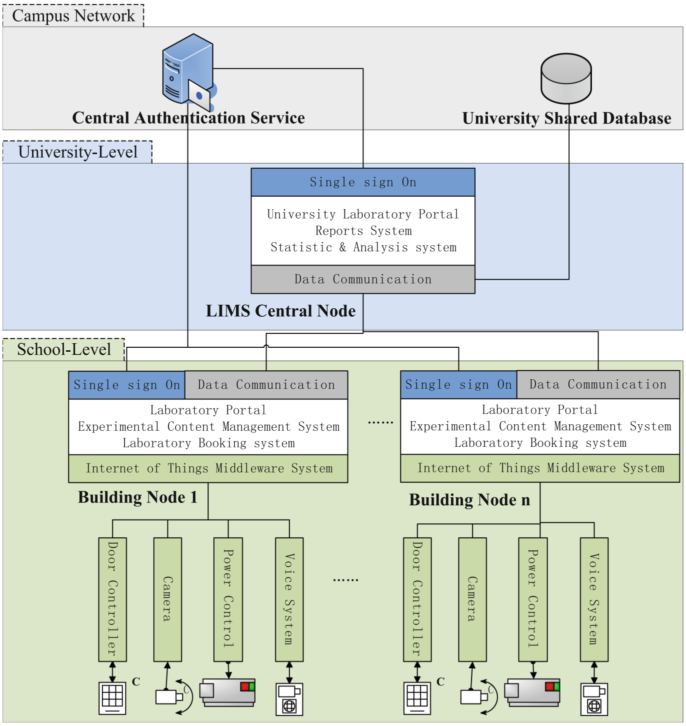

Fig. 1. The architecture of the LIMS in our University

situation, reports and statistical information of all the laboratories. There are three main functions in it. First, it verifies user identity from CAS by using Single Sign on (SSO) technology. Second, it obtains course schedule, student list, laboratory information, etc. from University Shared Database. Third, it maintains the original data for reports and statistical information used by Academic Affairs Office, Department of Graduate and Department of Asset Management, etc.

School Level Platform is a set of Building Nodes deployed in each building. The Building Node, the laboratory portal for each School, is a set of software system and related hardware, such as laboratory portal, LRS, ECMS, IoTMS, door controller, intelligent power controller, monitoring system and so on. There are four main functions in it. Firstly, laboratory portal represents all information about each laboratory, such as equipment information, room information, experimental projects category and schedule of each laboratory. Secondly, by using the ECMS, teachers can maintain experimental contents and students can view them by using the Internet. Thirdly, through LRS, teachers can reserve laboratories for their ex course experimental contents, and students can reserve laboratories they are interested in during opening hours. Finally, door controllers, monitoring systems, power controllers and voice systems are integrated by IoTMS.

The LIMS is the experimental work entrances and is used by teachers and students for their daily experimental work. They can find the course experimental arrangement, opening hours and experimental contents of each laboratory. Teachers can reserve laboratories for their course experimental contents. Students can reserve laboratories for their studies and do courses experiments in reserved times. Managers can monitor and control the status of each laboratory remotely.

2.2 The Challenges Facing the Organization and Development of the LIMS Project

To elicit requirements, suggestions, bug reports, sum up experience and lessons, a LIMS presentation center was built in 2013, which is used to present the LIMS, communicate within stakeholders in our University and with visitors from other Higher Education organizations. A lot of meetings were launched, and hundreds of RE management group members, outsourcing development team members, and visitors from more than 30 higher education organizations present and give professional and valuable information. The following challenges are concluded from project experiences and meeting summaries.

- **Organization** issue: Due to the insufficient number of full-time IT staff, this project can only be carried out in the form of outsourcing. The interim project management team comes from various Departments and Schools in our University, how to organize and coordinate a part-time team for project management efficiently?
- **Personnel change** issue: As a University-level project, the project participates in numerous personnel. Customer-side stakeholders include organizers, managers in departments and schools, agency staff, IT staff, laboratory directors, laboratory administrators, faculties, doctoral students, graduates and undergraduates. The

outsourcing development team members include business personnel, project managers, development managers, architects, designers, developers, technicians. These participants are changing constantly. Some Customer-side stakeholders leave this project because they are retired or changed jobs. Some outsourcing development team members quit. New arrivals are difficult to take over the project in a short time.

- **Requirements change** issue: As the project progresses, new hardware requirements and software functional requirements are exposed continually.
- **Budget increase** issue: To strive for more projects and greater benefits, the outsourcing company will try to increase the budget continuously. Some of the additional budgets are reasonable and others are debatable. The company has proposed that in order to allow the monitoring subsystem to run smoothly an independent optical network throughout the campus should be built.
- **User complaints** issue: Users will have a strong negative mood on the project when their requirements, suggestions, and bug reports have not been answered promptly and solved effectively.
- **Legacy systems** issue: At the beginning of the LIMS project, some schools already have some legacy systems. Ideally, these legacy systems should be integrated or replaced with better systems with the development of a University-level platform. After these years of attempts, some systems, such as LRS of SoCST, are replaced by a new system that is harder to use. Some of the original systems, such as the LRS of SoCCEB, will be replaced; some systems, such as the LIMS of the SoMSE, are still not integrated. A developer is often involved in multiple projects, and they will complain that some requirements cannot be achieved at the technical level.
- **Evaluation issue:** At the start of the current stage, we would like to hire a professional supervision company to supervise the project, but the plan cannot be implemented because the budget does not appear in the application. How to monitor and evaluate the project effectively by ourselves?

3 A GRADE RE Management Model Based on the Co-creation of Value

3.1 Requirements Engineering

Chemuturi describes the definition of requirements engineering: A requirement is a need, expectation, constraint or interface of any stakeholders that must be fulfilled by the proposed software product during its development. Engineering is a process of converting the specifications of customers into such artifacts that are used by artisans to produce the product that fulfills the customer specifications [6]. Nuseibeh & Easterbrook proposed that the primary measure of success of a software system is the degree to which it meets the purpose for which it was intended. Broadly speaking, software systems requirements engineering (RE) is the process of discovering that purpose, by identifying stakeholders and their needs, and documenting these in a form that is amenable to analysis, communication, and subsequent implementation [7].

According to these authors, many delivered systems do not meet their customers' requirements because of ineffective RE. RE is increasingly recognized as an important activity in any systems engineering process. Effective RE will continue to play a key role in determining the success or failure of projects, and in determining the quality of systems that are delivered.

There are different models that have been developed for RE. The process oriented approach mainly emphasizes the transformation way between the input and output of the system, thus its data and control is not very important. The traditional structural analysis method SA and SADT belong to this category [8]. The data oriented approach emphasizes the formal description of data structures and analysis of the state of the system [9]. The JSD and the Entity Relational (ER) model are data oriented. The control oriented approach emphasizes synchronization, deadlock, mutual exclusion, concurrency, and process activation and suspension [10]. Data flow diagram is a typical control oriented method, and SADT is supplemented by a control oriented. The analysis of object oriented method is based on system objects and interaction among objects, which makes it possible that requirements can be defined and exchanged by three basic frames of method, objects and their properties, classification structure and collection structure [11].

However these methods do not take into account the users' values when considering RE. For RE to meet the users' needs, it is important to consider co creation of value.

3.2 Co-creation of Value

Woodruff defines customer value as a customer-perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitates (or blocks) achievement of the customer goals and purpose in a use situation. Co-creation of value is a model in which value is created not only through the joint activities of providers and customers but also the activities of others in the networks of these parties [12]. Prahalad & Ramaswamy argued that co-creation of value allows each customer to cooperate with the company, share experience, realize the interaction fusion of high quality, and the value must be created by the company and the customers together. individuals must be able to co-construct unique value for themselves through customer network interactions that facilitate contextualized experience outcomes through Dialogue, Access, Risk management and Transparency (DART) [13]. O'Hern & Rindfleisch proposed a typical step of co-creation of value: First of all, clearly define target item. Secondly, find the right customers who need to be integrated into the project. The sources of customers are changing constantly and customers tomorrow may be different from today. Thirdly, cooperate with customers to find out what they really need in the product or service. Fourthly, design products and systems jointly to meet the production needs of those special ingredients. It also requires companies to choose appropriate partners to integrate into their own production and operation network. And fifthly, decide how to share value. Lastly, overcome all kinds of resistance from the internal network such as distributors, customers and business partners. This is a critical step to ensure that companies can effectively control the various channels [14].

According to these researchs, the activities of the co-creation of value are to find and organize stakeholders, keep communicate with them in the product or project process, manage risk and share value.

3.3 A GRADE RE Management Model Based on Co-creation of Value

In order to solve the challenges encountered in the project, based on the experience and lessons of these years, using co-creation of value in RE of the LIMS can be concluded as Group, Risk Management, Access, Document, and Easy to Use (GRADE).

- **Group** is used to find and organize customers. All stakeholders are organized into a project group consisting of a technical team, a working group and a coordinating team. It is used to deal with organization issue.
- **Risk Management** assumes that if stakeholders become co-creators of value with projects, they will demand more information about potential risks of systems, but they may also have to bear more responsibility for dealing with those risks.
- **Access** responses to stakeholders' requirements, suggestions, advices and bug reports helps them construct their own experience outcomes. To reduce user complaints, improve user satisfaction, it is essential to cooperate with stakeholders to find out requirements and let them access responses in form of documents or functions in systems.
- **Document** all design, organization and development activities. RE is involved in whole lifecycle of software system. The staffs and developers are changing constantly and staffs and developers tomorrow may be different from those of today. The project should be centered on the document rather than the key peoples. New arrivals can take over the project in a short time. Document integrity will affect the development of new features, legacy systems integration and upgrades, system evaluations, and acceptance.
- **Easy to Use** is an important factor in information systems involving user satisfaction and user complaint rate, which can be used to effectively improve user satisfaction and reduce user complaints. Users do not care about the complexities of the design and implementation phases, they just want to make day-to-day work more efficient and less complex by using a friendly user interface.

By using this model to analyze the project, it is found that the Group and Risk management of the project is good, but the Access, Documentation, and Easy to use are poor. These experiences and lessons will be explained in the next section.

4 The Case Study

Since our University has not enough IT staffs resources for the LIMS project, the project was outsourced to an external software development company as an "upgrade external project [6]". This section will analyze the organization and development process management of the LIMS project with the GRADE model, describe the usability and implications of co-creation of value in dealing with challenges in the LIMS project.

4.1 Group

Group is a good form for co-creation of value. All part-time stakeholders are organized into a project group consisting of a technical team, a working team and a coordinating team. The members of these teams are managers, laboratory directors and laboratory administrators, faculties etc. from related Departments and Schools.

The technical team members are staffs of IT Departments and faculties of laboratories with IT background. They elicit requirements from working team and different Departments and Schools of our University, document these requirements and communicate with the outsourcing company. The working team members are staffs from Academic Office, Postgraduate Office and Asset Management Office, laboratory directors and administrators and faculties from schools of our University. The coordinating team members are managers from Academic Office, Postgraduate Office and Asset Management Office. It is the most important team and is used to take charge of budget, risk and resistance from Departments, Schools, outsourced companies, etc.

By using of the Group method, all part-time stakeholders are involved in a co-creation of value environment. It is useful to solve organization issue.

4.2 Risk Management

Risk Management involves all stakeholders into the project, they will demand more information about potential risks of systems, but they may also have to bear more responsibility for dealing with those risks.

By considering of requirements change, The LIMS project is divided into three phases. 4 Schools were involved in the first stage from 2011 to 2012. Other 8 Schools were added to the project in the second stage from 2012 to 2015. New functions were added in the third stage since 2016. A LIMS presentation center was built in 2013, and a lot of useful requirements, suggestions, and ideas etc. have been elicited and gathered in form of new requirements by communicating within stakeholders in our University and with visitors from more than 30 other higher education organizations. New requirements gathered in the previous stage are integrated into the requirements of the next project. The entire LIMS project is developed in an iterative form.

The outsourcing company had proposed that an independent optical network throughout the campus should be built for the monitoring subsystem run properly in 2nd stage of the project. When confronted with this challenge, the coordinating Group convened a meeting of technical specialists, managers and IT staff. The participants obtained three conclusions by analyzing the original design and the actual demand. (1) The original monitoring system design scheme is distributed and integrated through the campus network. (2) The monitoring system is mainly visited within each building, and the number of cross-building access is less. (3) Considering the huge construction and late maintenance costs of an independent optical switching network connected to more than 20 buildings, this is a terrible idea. Finally this unreliable proposal was rejected.

The Risk Management method is useful to deal with the requirements change and the budget increase issue. The impact of requirement change is mitigated through a comprehensive phased approach. The reasonable and unreasonable budget increases in the project are judged by the expert meetings based on the initial design and actual requirements.

4.3 Access

Access means stakeholders can access responses of requirements, suggestions, and bug reports promptly and effectively. Access is a manner of elicit requirements by using of co-creation of value with stakeholders, and it is useful to resolve user dissatisfaction issue. Although many measures, such as weekly meetings, teleconferences, Instant Messaging (IM) system and Contents Management System (CMS) were used in this project, the effect is not good. The reasons of stakeholders cannot access responses of requirements, suggestions, and bug reports promptly and effectively are not only technical issues, more from the mental model and interests of decision makers and managers in the project. This requires a systematic methodology and solution that allows decision makers, managers, end users and developers to win together.

4.4 Document

Document all design, organization and development activities. It is useful for personnel changes, integration and substitution and evaluation issue.

Through the documentation approach, the project is centered on the document rather than the key peoples. New arrivals can take over the project in a short time. Development and evaluation are based on these document.

As time went on, the legacy system will be replaced by new system now or later. The completeness of documents about the APIs and functions of the legacy system will determine the degree of ease of integration and substitution. The completeness of documents of the current LIMS will have an impact on future systems. When we are developing a system, we not only need the system, but also need the documents. Statistical data, requirements response rate, requirements satisfaction rate, etc., can be counted based on the data in documents, which is useful to evaluation issue.

4.5 Easy to Use

Easy to Use is almost the most important issue to this system. If users feel that a new system makes their day-to-day work easier, they will be happy to use it, or they will complain and resist the use of it. For example, some users feel that the booking system is not easy to use, and is unwilling to use, resulting in the inaccurate statistic results in Fig. 2.

The statistical function of the system is very powerful, the interface is pretty good. Unfortunately, some of the statistical results are inaccurate and incomplete. One important reason for these results is that the user feels that the system is not friendly and unwilling to use. For ordinary users, the LIMS for experimental teaching and laboratory management is only a icing on the cake, with no use of it, experimental teaching can also be carried out. If users feel it is cumbersome, they will replace all or part of functions of the system in some other way, these alternatives can be manually filled out the application form, face-to-face communication, mail, telephone or other instant messaging tools.

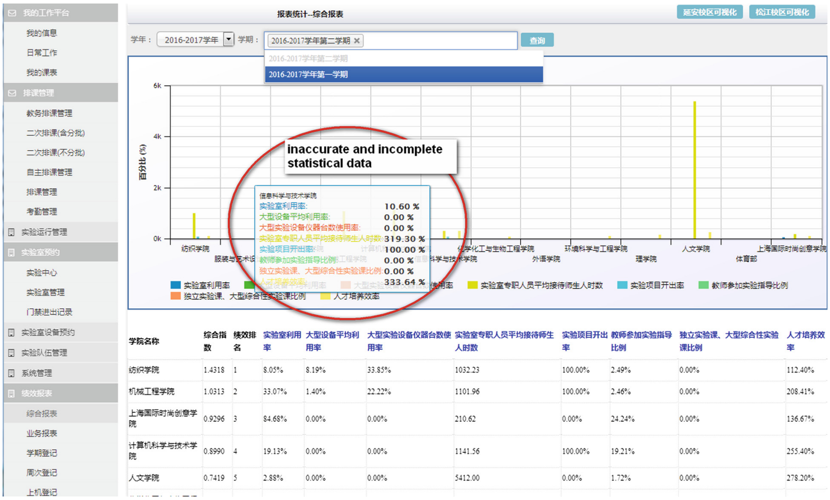

Fig. 2. The inaccurate statistic results in the LIMS

Figures 3 and 4 are different reservation interfaces of the new LRS in the LIMS and the legacy LRS in SoCST. Figure 3 shows the reservation status from the 2 dimensions (the week and the section). Reservations of different laboratories are putted in one week-section block. Figure 4 presents reservation status from 3 dimensions (the week, the section, and the Lab). Both of the new and legacy LRS can implement laboratory reservations in functionality by a pop up reservation interface when the Week-section block in the new LRS or the reservation button in the legacy LRS is clicked, but the reservation function in the new LRS is more cumbersome for that the a course group must be selected when users reserve laboratories, and the course group cannot be added directly in the reservation interface. Many users complain because they can't find the course group and don't know how to add it. In some schools there is no the concept of course group, and the company force all users to make reservations in the form of course group for that it want develop a common system. In the legacy LRS, new courses and experimental projects can be added directly in the reservation interface.

Users find the new LRS difficult to use because there is a lack of co creation of value used in the design and development process of the system.

As it can be seen the users' requirements are fundamental to the design and development of the LIMS. The developers need to co-create requirements' values with all stakeholders in order to make sure that the requirements meet user's expectation and values.

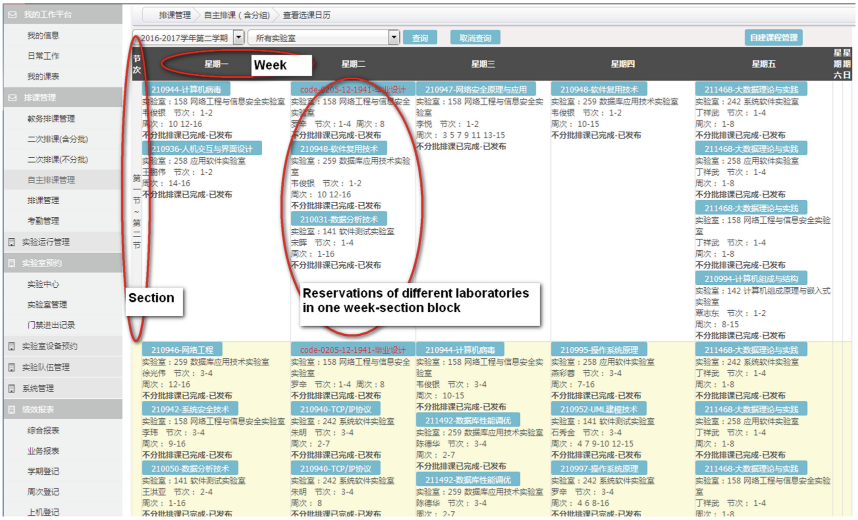

Fig. 3. The 2 dimensions (week and sections) main reservation interface of the new LRS in the LIMS

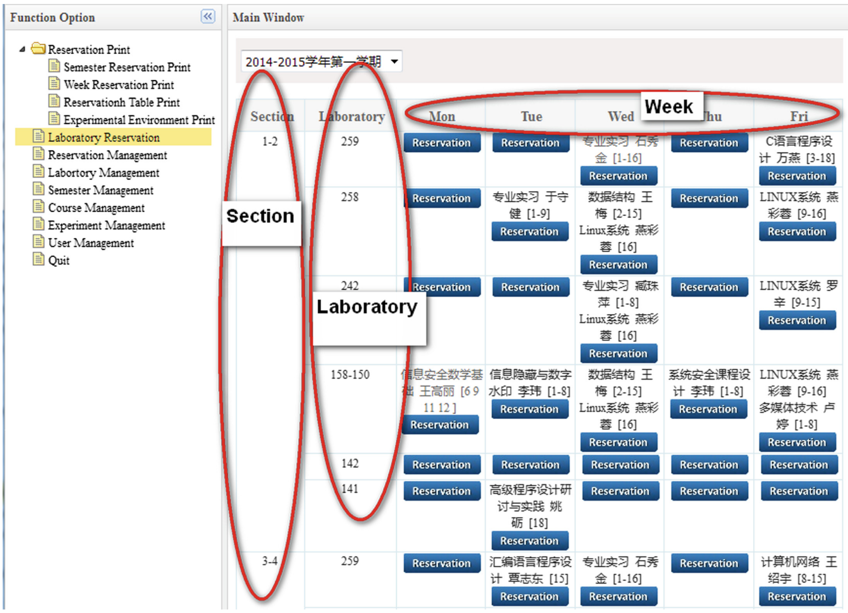

Fig. 4. The 3 dimensions (week, sections and laboratory) main reservation interface of the legacy LRS system

5 Conclusions

An effective LIMS is very important to help laboratories running effectively. Since the LIMS is a new innovation application and there are no mature product available. High education organizations have to design, organize, and develop the LIMS by themselves. The design, organization and development of an effective, usable and user-satisfied LIMS is not trivial. Users' values can only be determined by the co-creation of values with them. Designers cannot determine the users' values. Using co-creation of value in RE is important for an effective LIMS.

The LIMS design in the second part of this paper describes a layered and modular distributed LIMS system, which is mainly used for the design of individualized customized LIMS at University level, and also provides reference for School level LIMS. The GRADE model described in the third part and fourth part of this paper is essentially a theoretical RE management methodology based on co-creation of value, which is applicable regardless of the development method, development platform, and development and running environment of the development team.

Because the co-creation of values is still new in software development, it is useful and important not only in organization, requirement and design stages, but also in development, deployment and later maintenance stages. It is important for research to develop models that can be used to help organizer, designers, developers and other stakeholders to co-create values. It is our intention that co-creation of value models will be developed for IT domain to develop usable and effective systems that users can always have positive experiences when using it.

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Towards a New Learning Culture in Distance Education

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Abstract. The role of a university has changed crucially during the last decades, from scholastic university with focus on teaching towards the classical (Humboldt (https://en.wikipedia.org/wiki/Humboldtian_model_of_higher_education)) model of a "unity of research and teaching", and it is about to expand into a "creative university" [38] as an innovative "unity of praxis, research, and teaching" (compare Scharmer [33], Pinto-Coelho [30], and Peters [29]). Digitalization and Globalization influence and change didactics, roles of universities and lecturers, bring about new methods, tools, and learning scenarios, and lead to structural changes. The FernUniversität in Hagen is the only state-maintained distance teaching university in Germany (Distance-University (Distance-Universities base on Distance-Education [29]. Students do not have to physically attend courses. Still there are models of Blended Learning and Exams have to be taken in local universities.)). Since the foundation in 1975, the structure and concept changed from correspondence courses to models of online- teaching and -learning: e-Education. As a unique example in Germany, the paper discusses the structural changes and its acceptance by the teaching staff.

Keywords: Distance-learning · Distance-education · Distance-university · e-Learning · e-Education · Online-learning · Virtualization · Correspondence-courses · Online-courses · Learning university · Change · Innovation · Learning-culture · Higher education

1 Introduction

This paper presents a study on the development of academic distance-education from correspondence courses (printed textbooks, communication by exchanging letters) to e-education (i.e., teaching activities based on e-learning, online courses and digital course materials, communication by using synchronous and asynchronous digital media). Internationalization and Digitalization are the topics frequently discussed in the context of higher education in Germany. Nevertheless, the difference between concepts for traditional universities (augmentation and integration) and concepts for distance-universities are rarely considered in the aforementioned discussions. Thus, this study aims to analyze the effect of this restructuring of teaching on didactics and distance-education and the organizational change to a raising implementation of digital media. Rather than an evaluative comparison of old versus new forms of teaching, it

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presents a pragmatical discussion of the resulting didactical changes, using the example of distance-education at the FernUniversität in Hagen, Germany [1].

The paper is structured as following: Section two describes the methods used to conduct this study. Section three discusses the background on the development of distance education in Germany, the changes of roles and learning culture, and then the subject down to the example of the organizational and structural process of implementing e-education at the FernUniversität in Hagen. These are discussed on the basis of five guided expert interviews (section four) with professors teaching at both undergraduate and postgraduate levels (i.e., B.A. Bildungswissenschaft (educational science) and M.A. eEducation). The related curriculums were chosen due to their particular relation to aspects of teaching, didactics, and eLearning, but also because they depict a sector of the FernUniversität in Hagen where the implementation of digital tools for e-Learning and e-Teaching (compare Murphy et al. [23], Bennett et al. [2], and Handke [13]) and the associated programs are especially advanced. The conclusion in section five presents the findings of the interviews in context to the initial question and the wider context of e-education as a new culture of learning and its potential for social change.

2 Method

The research method combines textual work with a qualitative analysis of expert interviews. MAXQDA[1] is applied for data collection and analysis. This is adequate to the complex dimensions of an institutional structural change which needs to implement the state of the art of related theoretical and empirical discussions [10] as well as subjective points of view and knowledge of experience, construction and context (compare Gläser and Laudel [12] and Przyborki and Wohlrab-Sahr [31]) of the teaching staff. Reinmann [32] describes the inclusion of “emotions as energy for each kind of individual and collective learning” as a precondition for successfully implementing e-learning. This applies in twofold regard to the context of this study, as the implementation and the acceptance of new technology for learning by the teaching staff require media & computer literacy and collective (corporate) learning.

The literature on the development of distance education is extremely complex. The textual work of this study filters relevant literature on the development of distance education in Germany and at the FernUniversität in Hagen, with specific regard to the main issues discussed in section three. This university plays a unique role, as it is the first and the only public distance university in Germany. The literature was analyzed and coded using MAXQDA. In the first instance, codes were used deductively to create subsequent codes and categories for the interviews. As a second step, using the interviews, an exceeding and complementary inductive coding was effected; following Flick [11], and Cropley [5], and Grounded Theory [5]. This approach facilitates to gain insights and parameter which would have got lost using a mere deductive coding

[1] A software program designed for computer-assisted qualitative and mixed methods data, text and multimedia analysis in academic, scientific, and business institutions (https://en.wikipedia.org/wiki/MAXQDA).

(compare Flick [11] and Kuckartz [22]). The choice of the five interviewees (four active teaching professors, and the founding director of the FernUniversität in Hagen) included professors who have been actively teaching since times of the "traditional" distance-education and experienced and witnessed the restructuring of teaching, as well as professors who were appointed at a time after the implementation of eLearning/eEducation on campus. Gender parity [23, 37] was considered, and thus there were both, male and female interviewees.

A list of the codes and the anonymized interviews can be requested from the author as an inclusion would go beyond the scope of this paper.

3 From Correspondence Courses to eEducation: The Development of Academic Distance-Education in Germany

> *"Distance education in higher education does not mean a mere translation of lectures into the self-instructional material. It is more flexible, autonomous and critical-reflexive way to study. Studying is different from learning in school, from instruction. It cannot simply be transferred into the development of distance education" (translated from Dohmen [8])*

For many decades the traditional form of academic teaching and learning took place exclusively in the national universities and was open only to a small percentage of citizens. This started to gradually change since the 1960 s, due to the increased birthrate and populations and the subsequent trend of educational reforms. The traditional teaching form of the classical lecture which was conducted in a lecture hall, soon reached and exceeded its limit and led to a search for alternatives, respectively possible amendments. And first models of distance education in higher education were exactly this: Amendments which were less new forms of teaching than complementary offers, to teach and learn the same curriculum, but to reach more students. It was started with offering additional distance courses for propaedeutic, or during the semester breaks, or to study presence- and correspondence courses on a rotational basis (which enabled to double the number of student cohorts by offering both options). Also, rather focusing on deficits or expressing it provocatively, the first distance-university did not define itself as a competitor to traditional institutes of higher education but as »collecting pit« for students who (for whatever reason) were not able to attend »normal« universities. This attitude changed when e-learning became a trendy topic in scientific discourses. "New technologies enlarged the spectrum of teaching and learning forms barely conceivable before […] one could think they were invented and developed specifically for distance education" (translated from Peters [27]). With the rising demand for distance education, a continuously increasing amount of approaches strived to offer equal, but not identic didactical concepts.

3.1 Crucial Changes in Distance-Education: A Break with Academic Traditions

"Distance education is a format of learning and teaching which is by no means clear-cut and fixed. On the contrary, it has always been in a state of transition. Today it is in a state of rapid transition. […] If we want to understand the essence – and the real mission – of distance education, we should transgress the model of distance education which we happen to know and become familiar with additional concepts of this particular kind of learning and teaching" [29].

The previously mentioned development has opened higher education to a broader audience and changed it from being a rather elitist offer into becoming an at least theoretically opportunity for groups of participants that had been excluded from it before. What these new groups have in common is their heterogeneity which was different from former groups of »traditional« students. Not only the difference in social-economic status but the differences in age and learning experiences, previous knowledge (from previous studies, job-experience, or professional life) started to play an important role. Traditional methods needed to be rethought, adapted and altered, and new ones had to be developed in order to offer adequate scenarios to these new groups.

The question of **didactics** (which hitherto was found only in discourses on school-learning, but not within higher education) became a highly controversial topic (compare Dohmen [8], and Ortner [24], and Huber [16]). Especially in the context of distance education, which lacks the traditional element of didactics in higher education, the lecture, Huber claimed the necessity to structure scenario and media for teaching especially thoroughly (compare [16]). The core elements of the traditional distance-education were courses- and textbooks, written: "in a personal appealing language" (translated from Dohmen [8]), to encourage and motivate students to reflect and understand complex contexts. It, therefore, had to be scaffolded in small digits, including questions, excursus, interim conclusions and summaries, and to enable a kind of dialog with the students who wrote answers and small essays, sent those to the universities and got written feedbacks and marks. As a main point of criticism was a "didactical impoverishment" by reducing the process of studying on writing (missing listening and talking), moreover, elements like TV and/or radio lectures, audio recordings and audio courses (enabling a spoken dialog by recording questions and answers and exchanging cassettes) and presence- seminars (blended learning) were added (compare Dohmen [8]). The latter also had to be different from traditional lectures as Dohmen [8] emphasized, as they were not stopgaps but an opportunity to deepen the learning of the content previously studied by the students. Therefore, such direct courses needed a specific concept aligned with the needs and requirements of distance students.

Not only didactics and programs but also the **role- and self-image** of institutions and lectures were challenged to change. The role of universities changed from scholastic university with its focus on teaching towards the classical (Humboldt) model of a "unity of research and teaching" and is about to expand into a "unity of praxis, research, and teaching". The role of professors changes from "sage on the stage" towards coach and guide [20]. "Lecturers sometimes reacted surprisingly emotional on even slightly expressed critic towards the efficiency of traditional lectures. It seems that giving lectures is a crucial part of their self-image and professional role." (translated from Eckstein [9]. It is evident that the role of lectures has changed and requires new competencies in the context of choosing and using media and dealing with complex forms of learning-management-systems (LMS). It changed from authority and expert in behavioristic settings, towards tutor (cognitivism), coach trainer (constructivism) and participating learner (connectivism) (compare Daniels [6], Blumstengel [3], Holzinter [15], Kania [17], and Siemsen and Jansen [34]). But this should not lead to the conclusion that teachers/lecturers would become obsolete (compare Wildt [39]. Self-organized Learning requires competencies that do not come into being just because there are new technological opportunities and settings. "To offer technological tools does not automatically switch students into enthusiastic and autonomous learners" (translated from Flick [11]). It is still, or even more than before, the task of teachers to foster and enhance competencies, and the statement that a good teacher can compensate bad technology, but technology can never compensate bad lectures (translated from Gläser and Laudel [12] with reference to Hentig [14] applies for Higher Education as well. Kerres et al. [19] compare this new role with that of a gatekeeper, whose motivation and competence is the key role in establishing and anchoring innovative new forms and cultures of learning and teaching.

Otto Peters, the founding director of the FernUniversität in Hagen, tried to answer the question of how all these changes influenced the self-image and role-conception of lectures in distance-teaching. In 1981, five years after the foundation of the FernUniversität in Hagen, he reflected "impressions gained in countless conversations over these five years" and also interviewed lectures "with rich experiences in producing courses" (translated from Peters [25]) He included aspects like support (when producing courses), changed structures of work (like distribution of tasks), the necessity to find specific new objectives, communication with students, and dealing with different forms of media. He resumed that lecturers found substantial and considerable ways to communicate and conduct distance-teaching, and to interact with their students. They were willing and open for "didactical experiments", would suggest improvements, and therefore make important contributions to the discourses (and against the resentments) on didactics in higher education [25]).

3.2 Traditional Correspondence Teaching Versus E-Education

Neither can findings of other models of higher education be transformed 1:1 on distance-education, nor can it be expected to find a media-didactical approach which transfers distance-education into a virtual setting like e-Education. According to Peters [27] it is a matter of something totally different, to add elements of online-learning to traditional brick and mortar settings, or to use the potentials of digitalization to create new forms and approaches to teaching and learning, which would lead to crucial structural changes.

Peters already referred to digital media, which at this time were just at the beginning of changing inflexible sequences of communication into simultaneous and dynamic dialogues (translated from Peters [27]). While at this time (1995) connectivity and speed of online communication still foiled such designs, today it is possible to work in virtual environments almost without the least delay. Instead of accessibility, usability became the key role for the creation of online-learning-scenarios. Software and LMS like Moodle, or Elias, and Virtual Classrooms, enable to use, create and update materials in manifold ways without knowledge of coding, and it enables to communicate with students asynchronous as well as synchronously. All this became manageable and comfortable but nevertheless requires media-competency to insert and use the "*technological* functions of the digitized learning environment that deserve the special attention of instructional designers" [29]. And media like Virtual Classrooms, which enable participants to interact using microphone and camera, even bring about questions like if it would be necessary or at least adequate to re-define "blended learning" for the context of eEducation. Kania (translated from German [17] stated in his Dissertation that "buzzwords like Virtual University, virtual campus, distance- and online-leaning all could be summed up as elearning and would extend – in combination with conventional forms of teaching and learning – to Blended Learning". But is it really so simple? Traditional didactics and course-conceptions from Brick and Mortal Universities + Media-Didactics + elearning = Blended Learning = Didactical Model of distance (e) education? Usually, blended learning is used to describe scenarios where phases of (self-organized, autonomous) learning are combined with phases of (local) face-to-face presence. Assuming that the latter should, first of all, compensate deficits like lacking social presence, solitary learning, and face-to-face communication, one could ask if all this is not also possible using a virtual classroom and video and audio for synchronous learning-sessions, to enables cooperative learning and to fosters social presence, and to offer similar or almost equal opportunities but much more flexibility.

4 Structural and Organizational Switch at the FernUniversität in Hagen, Germany

The FernUniversität in Hagen is the first German distance-university offering a concept for Higher Education on the level of traditional universities. It was founded in 1975 with three faculties, 11 chairs, 120 academic staff and 1331 students enrolled. The didactical concept was printed correspondence courses, which were sent to the students by letter-post [7]. In 1977 LOTSE (an electronic system to evaluate and mark exams) was implemented 1980 the university inserted a computer as a host which enabled the implementation of teletext and two years later first established networks with linking to the students' home computers. In 1985 first texts were digitalized, first floppy discs were sent to the students and the university started the development of digital courses. In 1986, it became possible to access material via the internet and 1992 the staff was instructed to use software for teaching. In 1993 the first connected network of the workplace computers was realized. Enabled by ISDN and broadband first video-conferences took place, hypertexts were implemented and in 1996 an "all-around software infrastructure for web based practical training on the basis of Web Assign", and 2000 the first "central technical platform for web-based studying" came into being [28]. In 2004 the "Environment Virtual University" officially became the concept to enhance modern teaching and learning and communication and support" (translated from [35]. In 2012 (the year the here presented study was conducted) 80 chairs, 357 academic staff, and 59 assistant lectures supported and took care of 79.679 students of four faculties [36].

Corporate elearning (and e-teaching) as a holistic solution [21] is a challenge for each organization – exceptionally, if e-learning is not only a learning process for the staff but at the same time the organization is an academic institution, its working method didactics, its core concept distance-education and its claim and approach the ideal of the freedom of teaching [4]. The following section complements the up to here theoretical analysis with its relevance for the everyday working life of the teaching staff. How did the structural changes from correspondence courses and former face-to-face teaching towards online-forums, Moodle, digital material, and other virtual tools influence profession and self-image? Kerres and Stratman [18], as well as Peters [26], considered these changes as challenge and task, to recognize and implement the new technologies, with the established stuff and within their organizational structure. "In Hagen, however, the professors have offered the possibility of increasing the availability and accessibility of their teaching by becoming acquainted with important aspects of educational technology" [26].

5 Expert Interviews

> *"The question of successfully graduating does not first and foremost depend on a perfect didactical concept, or of a sufficient number of experts in administration, production, and distribution […]. It depends on chairs and teaching staffs ability and willingness to find a positive attitude and to commit themselves to new and specific approaches of eEducation, which are very different from those they were educated and cultivated with"* (translated from Peters [25]).

As the original interviews have been conducted in German, the following session is a translation of the crucial statements which are formatted using *Italic* to distinguish them from the original text records of the interviews. Key-Aspects selected via MAXQDA (a software program designed for computer-assisted qualitative and mixed methods, see also section two) are formatted using **Bold**.

The interviews underlined that **newly appointed chairs and teaching staff** at the FernUniversität in Hagen almost solely come from a traditional Higher Education background, and from Brick and Mortar Universities. These may meanwhile implement elements of online teaching/online-learning into programs. However, as shown above, their approach is a totally different in Didactics than e-Education at distance universities. For **those who have already been employed** before and/or during the structural changes (increasing digitalization and virtualization) a re-adjustment is different but nevertheless challenging. They argue in regard to **changes in Didactics** that "*there has been little* ***innovation****, just an increasing use of different tools. And it is more about the new combinations of tools, rather than if new tools were not offered. Nothing that has not been there before"*.

As shown on the analysis of the literature, the interviews' results imply that there is no clear-cut definition for **Online-/eLearning-Didactics –** at least to the interviewees. For example: "*I consider talking about the Didactics as essentially problematic …*

Didactics is something that depends on individuals ..., it depends on characteristics of teacher and students ... it would be fascinating to reflect on it, but this implies further research ... Nobody can tell me that it is possible to mirror a traditional academic course (attendance-based) by dismembering its elements and putting them together again in a clever way. This is something different. Even if you argue, with a social media tool ...this kind of learning is an individual and solitary task, and one has to be able to, to have the skills and the competence. And as it is different in structure, there is the need to develop a specific Didactics and therefore you also need a theory if you want to accomplish it in a reasonable way.

Another argument which is not found in the literature was expressed in the interviews. Many recent **changes of teaching structures and teaching tasks** are not (only) due to Digitalization or Virtualization, but due to the change towards the B.A. and M. A. restructuring of courses and programs (Bologna Process[2]: Germany did not have BA and MA degrees before, but "Magister" and "Diploma").

When discussing assistance/support for students, all interviewees still regarded phases of **local face-to-face attendance** as a crucial and basic element in the teaching activities. As an example they mentioned the FernUniversität's concept of "Studien- und Regionalzentren" (German, meaning study centers situated at local universities in different parts of Germany, where students are offered (optional) **presence face-to-face sessions** in addition to the online courses, and where they take their exams) which were "*closely connected with the FernUniversität and where students could experience science and teaching ... how to enhance support and teaching. To reach different study centers and different environments where students are ... for me this is still a weak spot".* Local face-to-face-presence is predominantly described as having "*another workshop dynamic and atmosphere*".

Online sessions were considered as reasonable amendments which were "*tremendously complex & expensive*" but on the other hand could help students "*living in diaspora-like situations to get access to a reality of face-to-face sessions*". Nonetheless, they would not be able to replace local presence face-to-face-sessions, because this would lead to "impoverishment of impressions". It was mentioned as "*important that students can experience teachers/experts in person. If someone has spent his whole life with physics and then talks in front of the students, this will inspire them ... when they see this is someone who has written the books that we read ... then they will listen how he talks ... and by listening they will learn to talk equally. And this is difficult with digital teaching. There they will write (like experts) ... maybe ... but the processes of thinking which they experience face-to-face are dumped down by the digital channel...".*

All interviewees define **Blended Learning** as a combination of local face-to-face sessions with online sessions. There was no new approach to replace local face to face sessions by video-conferences in a virtual classroom. "*it is ... a mere virtual course, without phases of local presence face-to-face sessions ... even today, in a time where media offer plenty forms and opportunities to experiment ... yes, in my opinion, local presence face-to-face sessions are indispensable. You need to sit and discuss*

[2] https://en.wikipedia.org/wiki/Bologna_Process.

face-to-face". Moreover, in addition to traditional definitions, the interviewees also emphasized that these additional local face-to-face sessions could not just be adopted from traditional lectures without adaptions: "*Blended Learning, this is something that always annoyed me. Because (laughs) I believe lectures in local sessions at the universities and digital learning via online channels are totally different ... structurally different ... things. I cannot bear someone saying: yes, we make Blended Learning, by taking some elements of Brick-and-Mortar University concepts into our distance-teaching-concept ...embedded into 'the digital' part. These elements are not conceptualized for distance students but for people learning face-to-face. For me, this is not Blended Learning. It is against the structure of distance-learning and against digital earning. This is a really difficult problem."*

Asked how the structural changes influenced the **communication with students**, the interviewee's answers were as well different as distinguished. They mentioned that "*digital teaching offers many possibilities to notice student's perspectives, approaches, and opinions, which often would be missed in traditional lectures and local classrooms. Many of them are much quieter there, whereas in online forums interaction and communication are more active and informative*". In addition, it should be noted that "*in local face-to-face sessions participants could be 'coaxed out of his shell" which would get lost in the anonymity of the net".* An aspect which was often mentioned was that many elements/tools which could foster communication cannot be used because of the huge number of students. "*Many things which would be nice, technologically possible and didactically desirable will remain undone and left behind because of the masses we have to support. For me, very personally, as I have seen and experienced different forms of teaching during a very long period of time, this is a very big problem ... I regret that I often do not come to know the students who complete their studies here from the very beginning*."

All interviewees state that their **every-day working life** has crucially changed. Most of them described these changes as positive as they offer more flexibility "*to communicate with people, to interact more individually, to go deeper into individual interests ... which is something I cannot do at a traditional local university where I am involved and bound to ... yes to a kind of schedule which is relatively fixed and thematically not flexible."* On the other hand, time pressure, high expectations of the students "*which expect that such a rapid medium enables to answer 'by the way' ... immediately. They send e-mails in the evening and expect an answer latest the next morning. This is something we cannot always achieve."* Almost all of the interviewees saw positive and negative aspects at the same time: "*As a teacher, you are much more flexible. But you could be online day and night with teaching engagements.*"

Most of the interviewees considered that **the institutional support and assistance** like training, workshops or individual support in the context of the structural changes were poorly structured and did not take place in advance but at a late time. "*I was already too deep and far 'into it', at this time I did not see any additional benefit in the offers. And especially the elderly and more traditionally oriented sections were not included in this process in a sensible way."*

Like the interviews conducted by Peters in 1981 [25], this study shows a high level of motivation on the side of the concerned staff. They were open to experiment and to use new approaches, new tools, and new Didactics, like to conduct "*small opinion polls* *amongst the students, which can be done easily using Moodle, and where we can get a picture and impressions of what our students think ... about recent topics of educational politics .... transferring study content into praxis-contexts*". The recent structural changes enable the teaching staff to see potentials and opportunities which go far beyond individually changed structures of the every-day working life: "... *you can enable an unlimited number of students to enroll, to be supported, to get the chance to graduate. Especially for developing and also for emerging countries like China and India this plays a very, very important role. It is almost an act of humanity, to give these people the opportunity to graduate. Insofar distance-universities have a positive side which meanwhile is often not even mentioned anymore. John Daniel* (referring to [6] *focusses this, saying 'Megauniversity as a response to the great moral challenge of our age' ... isn't this the point, the positive aspect of it*?"

6 Conclusion and Desideratum

This study finds that the interviewees have a high motivation and openness towards new approaches and models of distance-teaching, but also there is a tendency to remain in traditional frames and to stick to a general understanding of Didactics which not fundamentally changed in the context of eEducation in virtual and digitalized scenarios. The "image" of the traditional university, of traditional roles and concepts of teaching and learning, still influence attitudes, values, and patterns, and remains in relatively narrow frames.

As described in Sect. 3.1, one of the most crucial changes in the context of the digitalization of Higher Education and hereof emerging global networks is a changed learning culture. Traditional roles, like experts (teacher) versus learners (students who have to be instructed), dissolve and merge. The teaching stuff is part of a learning community and supporting the generation of knowledge (which is what studying in contrast to memorizing/learning by rote means) is a learning process itself. This is where concepts for restructuring universities in the context of globalization, digitalization and networking have to spud in and where Huber [16], as early as in 1969, resumed that "Didactics for Higher Education must start and continually go on as a learning process of the lecturers".

Through literature and the empirical data, it shows that all aspects and key elements discussed and analyzed, using the example of a German distance-university, are also of relevance in other, much more complex and holistic contexts. Globally open distance-universities could become gateways for developing and emerging countries. Societal change, global networks, Digitalization and Globalization influence changes and innovation in the context of Knowledge-Societies and Higher Education - and vice-versa. Education became a resource for change and innovation. With new initiatives, education changes from a self-contained period in childhood and youth towards a lifetime process of enhancement, where periods of working and periods of studying alternate or even merge and the competence gained via self-organized study will be essential. Global Networks of distance-universities could become key actors and learning environments which foster and enable multi-stakeholder-networks where theory and praxis are connected and knowledge and innovation are generated and created. This would facilitate new learning culture where each participant shares and generates knowledge and the culture will be a part of a learning community, enabled through context reflectivity and re-thinking and re-framing hitherto roles, definitions, values, and patterns.

To analyze such a new learning culture and the vision of a global network of universities as learning-environments, in regard to its constituting elements (individual distance universities and individual learning process of the teaching staff), the question of quality management is an important topic. As Kania [17] states, most universities have a high fluctuation of staff, which means a high effort of Coaching, incorporation and on-the-job training. This concerns the discussed example of the German FernUniversität to an extremely high degree, as in this case staff do not only change the way university delivers the course, but also the form of teaching (digitalization), the educational/political frame (Bologna Process[3]), and general academic values and assumptions (from elitist to "massive open" and OER[4]). As the research has only studied FernUniversität, future research can compare this study with other distance education institutes from other countries and demographical factors may be brought in to enrich the findings.

To develop a sustainable system and structure of quality management, fostering continuous coaching as well as a training concept for staff coming from traditional university systems, and to include elements for specific areas of teaching as well as elements usable in a more holistic way for Higher Education itself, as described above, will be the most important challenges and tasks of the future for the FernUniversität to face.

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Applying PBL and SRL to Enhance Learning Strategies and Collaboration in a Blended Learning Environment

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Abstract. Studies are needed to investigate the features of e-learning environments in Higher education (HE) and highlight important issues, such as good practices, instructional design and techniques employed so that meaningful learning experiences can emerge. To this end, the design of an intuitive learning platform that integrates online and F2F learning following a well-established theoretical framework is proposed. Hence, the aim of the present study is the design and implementation of an instructional design workflow based on the combination of Problem-Based Learning (PBL) and Self-Regulated Learning (SRL), through a blended learning environment (apT^{2}CLE Environment) in an attempt to enhance students' learning strategies and collaborative skills. We conducted a quasi-experimental research within a computer science department of a university, throughout a university course. Participants, assigned to the experimental group, followed the process of implementing the proposed workflow through the apT^{2}CLE environment. The findings revealed that the apT^{2}CLE environment, designed along the lines of PBL and SRL, might enhance students' learning strategies and collaborative skills. Moreover, a future study should place emphasis on the instruments used to assess the indicators examined in this research.

Keywords: Problem based learning · Self-regulated learning · Blended learning environment · Collaboration · Learning strategies

1 Introduction

Higher Education (HE) institutions are seeking ways to adapt and use online and distributed systems offering a growing number of courses and programs [1]. It seems that there is a demand for universities to provide for a larger and more diverse cross-section of the population and technology-based practices in the curriculum [2]. It is thought that the convergence of classroom and e-learning is the single greatest unrecognized trend in higher education today [3].

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However, e-learning environments have been criticized for the lack of human interaction and high dropout rates, issues that concern several HE institutions. A number of studies have indicated that a higher percentage of students participating in an online course tend to drop out as compared to students in a F2F classroom [4]. Therefore, there has been an increasing movement toward blended learning approaches where students can have opportunities for both online and offline interaction with their instructors and classmates [5].

The focus should not only be limited on the dropout rates as evidence that online education has failed, but on researching how to improve performance in online learning environments [6] as well. Thus, studies are needed to delve deeper into the features of such environments and under score important issues, such as good practices, instructional design and techniques used to lead to meaningful learning experiences [7].

HE institutions should provide context-rich academic situations where students enhance their knowledge and upgrade skills, such as scientific thinking, research skills, problem solving and self-regulated learning skills. In light of this purpose, Problem-Based Learning (PBL) and blended learning environments can offer an opportunity for moving beyond content acquisition to develop skills and competencies needed for lifelong learning.

The present study, therefore, focuses on the design and implementation of an instructional design workflow based on the combination of Problem-Based Learning (PBL) and Self-Regulated Learning (SRL), through a blended learning environment (apT^{2}CLE Environment – applied psychology on Teaching and Technology Environment), to enhance students' learning strategies and collaborative skills. The principal goal involves the provision of an intuitive learning platform that integrates online and F2F learning following a well-established theoretical framework.

2 Theoretical Background

2.1 Blended Learning Environments: Key Issues and Challenges

Blended Learning Environments (BLEs) combine the advantages of e-learning with elements displayed by traditional physical classes, such as F2F interaction offering opportunities for innovative activities, including online collaborative learning [8]. It has been suggested that blended learning can be more effective and efficient as compared to a traditional classroom model, for it offers reduced costs, time efficiency and location convenience for the learner; it is also considered to foster personal contact and motivation [9]. Students participating in blended learning courses seem to adopt a positive attitude towards their classes and e- learning and exam success rates are higher, in comparison to conventional F2F learning [10]. Finally, blended learning can be effective in terms of addressing diverse learning styles [11].

For the abovementioned reasons, blended learning is becoming a trend in education and it is anticipated to become the "new normal" in higher education course delivery [12]. Yet, despite these benefits, there are challenges for students, such as time management, workload, course design barriers, and personal barriers. It seems that lower dropout rates can be achieved provided that online program developers or instructors find ways to enhance the relevance of the course [13] and the communication or social interaction among students and between the teacher and the students [14]. Therefore, issues like collaboration; relevant pedagogical content and well-designed educational activities appear to be of high importance, indicating that they should be taken into account when designing an online course. Fortunately, advances in modern communication technology have provided several tools to minimize these problems, offering flexibility of time and place and easily accessed educational content that best suits the learner's needs.

2.2 Problem Based Learning (PBL) and Self-regulated Learning (SRL) in Blended Learning Environments

PBL is an instructional method, which uses ill-structured problems in order to encourage learners to get involved in the learning process and to develop a set of skills for the 21st century (such as collaboration, self-directed learning, critical thinking and problem solving) [15]. In detail, PBL is a learner-centered approach to instruction in which learners collaborate in small groups on a series of real-world problems, which can be self-standing or linked [16]. To do this, learners need to activate prior knowledge and share their experiences with the group. The group then discusses the ideas presented, which encourages group members both to elaborate on their own thinking and to understand other learners' arguments [17].

In PBL, students engage in self-directed learning and work in collaborative groups to find what they need to learn, apply the acquired knowledge to solve the problems, reflect on what they have learnt and identify the effectiveness of the strategies they have employed [18]. In online environments, equipped with Self-regulated learning (SRL) competence, students seem to become more responsible for their learning and more intrinsically oriented [19].

Self-Regulated Learning (SRL) can be defined as "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process" [20]. According to Zimmerman's model, self-regulated learning consists of three phases (Forethought, Performance and Reflection), in which there is a variety of SRL strategies that play an important role in students' academic achievement [21].

However, there is a need for further research into the parallel application of PBL and SRL, particularly in a blended learning environment. This study partially addresses this need by investigating the ways in which combined PBL and SRL can improve student collaboration in an online course [18]. In this regard, this study helps to narrow this gap by exploring the effects of the combined intervention of PBL and SRL on enhancing students' collaboration in an online course.

2.3 Collaboration and Self-regulation

Collaborative learning is one of the critical components for PBL that has been used as an effective instructional method in traditional and in distance learning settings [22]. This means that there is a need to focus on the PBL experience to engage learners in practical-based activities and reflective practice. To this end, learners have to be equipped to work with various groups effectively. They also need to be flexible, willing and able to compromise in the drive towards a common goal, and able to share responsibility for a collective task without losing sight of the personal contributions of individual members. Literature review suggests that learners may develop collaborative skills associated with the development of, inter alia, team spirit, collaborative culture, collegial consonance, and Trusting Partnerships. More specifically [23, 24]:

- Team Spirit relates to the ability to work together on collective activities,
- Collaborative Culture is a broad term, which encompasses common expectations, mutual respect and concessions made within a collaborative group, but also learning, professional development and collaboration,
- Trusting Partnerships refers to skills relating to trust, respect and collective action,
- Collegial Consonance relates to the collectivity that emerges when people collaborate, discuss and share ideas, knowledge and techniques with their partners.

This can be achieved through the use of collaborative learning techniques and strategies, which, when applied in blended learning environments, offer learners the opportunity to experience the multiple perspectives of other distance learners from different backgrounds and to develop critical thinking skills through the process of judging, valuing, supporting, or opposing different viewpoints [25].

Additionally, Self-Regulated Learning (SRL) is a quintessential skill in collaborative learning, involving co-construction of shared task representations, shared goals, and shared strategies. It is argued that SRL would offer the student the ability to identify and properly evaluate the collaborative process. It also means regulating learning through shared metacognitive monitoring and control of motivation, cognition, and behavior [26]. SRL emerges from a socio-cognitive perspective, including strategic and metacognitive behavior, motivation and cognition aimed towards a goal [27]. Social context can offer opportunities for modeling, guided practice and receiving feedback [28].

2.4 SRL and Learning Strategies

Various studies focus on teaching practices that encourage learning strategies, establish collaborative student work, contain challenging tasks, and provide prompt feedback to help improve students' achievement and learning [29]. In this light, a major challenge for blended learning environments is to support learners into applying the appropriate learning strategies so as to guide their learning path [30]. The instruction and implementation of learning strategies in the learning process help students to strengthen their metacognitive abilities [31]. Thus, students' ability to select, combine, and coordinate learning strategies in an effective way, constitutes an important aspect in SRL [32]. Learning Strategies are goal-directed, voluntary activities that are not fundamentally required to satisfy an undertaking but are implied to facilitate performance [33]. Different types of learning strategies based on self-regulated learning can be grouped and may constitute the basis in the generation of the variables of our research. Specifically, learning strategies consist of Cognitive Strategies and Resource Management Strategies.

Cognitive strategies are classified in internal repetition, elaboration, organization, critical thinking, meta-cognitive self-learning strategies [34]. Organization strategies are activities that organize and structure the learning material, often with the aim to reduce information. Elaboration strategies refer to activities that are aimed at the understanding and longtime retaining of the learning content. Meta-cognitive strategies are strategies such as planning (setting goals, time scheduling etc.), monitoring (e.g., self-testing), and evaluating the learning process (e.g., rereading, self-assessment, self-reflection etc.) [32].

Resource Management Strategies, on the other hand, are used to manage and control the learning environment with the aim to support and sustain learners' motivation to learn. These strategies include time and study place, effort management, collaborative learning - peer learning and seeking for help [34].

3 Methodology

The design and implementation of an instructional design workflow based on the combination of Problem-based learning (PBL) and Self-Regulated Learning (SRL), which integrates collaborative indicators through an e-learning platform are put forward through this paper. Towards this, an e-course is developed for providing an overview of "research methods" and engaging students in practical-based experiences, ill-structured research problems and different components and methods in research. The overarching goal of the e-course is to provide knowledge and skills related to *research inquiry, scientific thinking and advanced understanding of research approaches.* We conducted a quasi-experimental research within a computer science department of a university, throughout a university course on Collaborative Learning Environments (CLEs). Students participated voluntarily and this research followed random sampling.

3.1 Research Questions

The objective of this study is to investigate the following research questions:

(1) Does a Blended Learning environment (apT^{2}CLE environment), designed along the lines of PBL and SRL, enhance students' learning strategies (cognitive & metacognitive strategies and students' resource management skills)?

(2) Does a Blended Learning environment (apT^{2}CLE environment), designed along the lines of PBL and SRL, enhance students' collaborative skills?

3.2 Participants

The sample of the study consisted of 70 undergraduate students who participated voluntarily. Participants assigned to the Experimental Group (N = 70) followed the process of implementing the proposed workflow through the blended learning environment (apT^{2}CLE environment) in an attempt to enhance students' research skills, scientific thinking, problem solving, collaboration and self-regulated learning skills.

3.3 Instruments

Participants completed a self-report as a pre and post-test to render the measurement of their perception on their abilities to collaborate and communicate within various teams flexibly and effectively plausible. A Likert-type questionnaire (from 1 = "Strongly Disagree" to 7 = "Strongly Agree") consisting of 24 items divided in sub-scales of collaborative skills has been employed. In particular, collaborative skills are associated with the development of the following qualities: Team Spirit (TS), Collaborative Culture (CoCu), Trusting Partnerships (TP) and Collegial Consonance (CoCo).

Furthermore, participants completed an adapted version of the Motivated Strategies for Learning Questionnaire (MSLQ- Part B: Learning Strategies) right before and after the research procedure to enable the measurement of self-regulation learning strategies [34]. This research focuses on the measurement of cognitive and metacognitive strategies before and after the intervention through the experimental procedure. A Likert-type questionnaire (from 1 = "Strongly Disagree" to 5 = "Strongly Agree") consisting of 50 items divided in sub-scales (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Resource Management strategies, including Time and Study Place, Peer Learning, Help Seeking).

3.4 Building the apT^{2}CLE Environment

We introduce the apT^{2}CLE environment, which is based on the open source learning management system, Moodle (Modular Object-Oriented Dynamic Learning Environment). The selected LMS is open, customizable, supports teachers, learners, administrators and developers, and provides a flexible toolset as well as an extensive plugins' directory for courses, activities, blocks, themes. Especially, Moodle has a set of standard features, such as: modern, easy to use interface, personalized dashboard, collaborative tools and activities, all-in-one calendar, convenient file management, simple and intuitive text editor, notifications and track progress.

The environment provides learners with a structured learning process that follows the principles of the PBL method, which commences with an ill-structured problem serving as the vehicle for the learning process. Furthermore, the PBL method is combined with self-regulation in order to support learners to plan, monitor and evaluate their learning path. The environment allows students to use various tools such as calendar, forum, chat, profile, dashboard, learning content, upload projects etc. Moreover, tutors can receive information about their learners' interaction and performance.

The vision behind the apT^{2}CLE environment is to provide an intuitive learning platform that integrates online and F2F learning following a well-established theoretical framework. What is more, apT^{2}CLE environment incorporates a comprehensive instructional design workflow along the lines of Problem based Learning combined with Self-Regulated Learning (See Fig. 1).

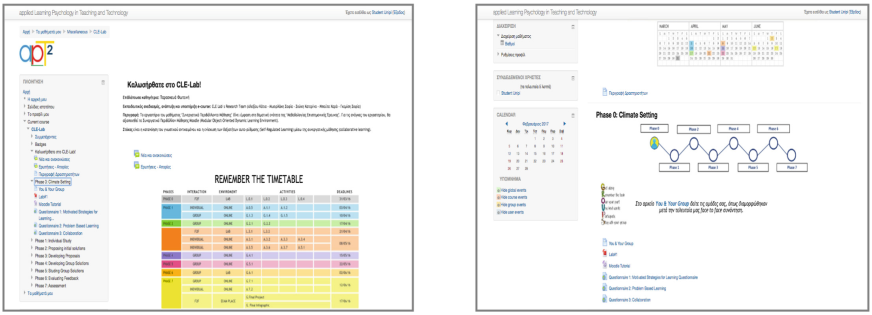

Fig. 1. The apT^{2}CLE environment.

3.5 Experimental Procedure

A research (one group only research) was conducted within a computer science department of a university, throughout a course titled “Collaborative Learning Environment”. The subjects of the study (N = 70) engaged in the proposed e-course in order to implement a research project for acquiring new knowledge and enriching their learning experiences. Specifically, students got involved in the following case: “As graduating students at the university and new researchers, please prepare your thesis. Which steps will you follow to deliver a robust scientific work?”

The experimental procedure follows the comprehensive instructional design workflow along the lines of Problem based Learning combined with Self-Regulated Learning, which consists of 7 phases.

The instructional design workflow is based on a PBL model [15], which consists of 7 phases and is aligned to the three phases of a cyclical model of self-regulation [21] so as to create a learner-centered environment and enhance collaboration skills. The learning process commences with the ill-structured problem, serving as the vehicle for the learning procedure and self-regulation has been embedded into the learning activity in order to support learners to plan, monitor and evaluate their actions and collaboration.

Analytically, students get involved in each phase of the workflow so as to solve the ill-structured problem (See Fig. 2):

SRL PHASE A: ‘Forethought’ Phase: Students (individual and group mode) enter the SRL cycle for planning their learning efforts. The primary aim of the initial phase (PBL climate setting) is focused on learners’ preparation, with regard to the learning process schedule, their assignment to teams, the clarification of their roles within their teams and their registration to the apT^{2}CLE environment.

In this phase students organize their learning path for understanding the principles of research methodology and implementing their research project. Each student, hence, gets involved in specific activities, including: goal setting and strategic goal planning and studying the ill-structuring problem.

PBL Phase 1: Includes studying the ill-structured problem via resources uploaded onto the apT^{2}CLE environment (individual mode).

PBL Phase 2: Encompasses teamwork (Forum & Chat) in order to comprehend the suggested solutions to the ill-structured problem (group mode).

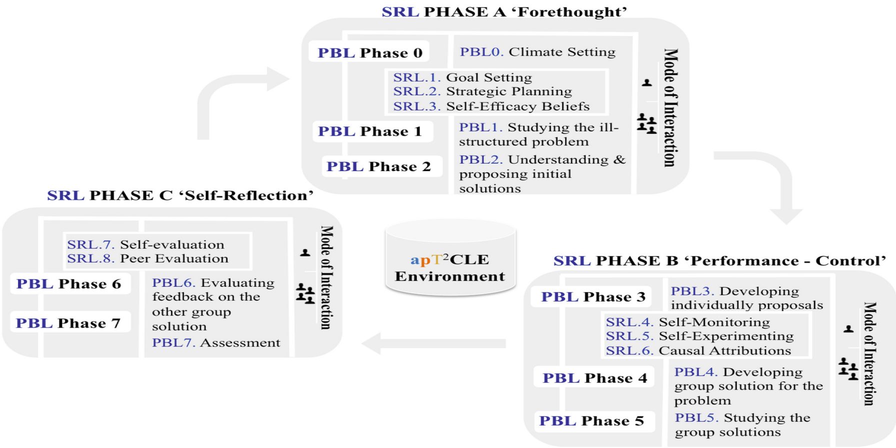

Fig. 2. The experimental procedure

SRL PHASE B: 'Performance Control' Phase: Students proceed to the second phase of SRL where they gather and elaborate on information that complements their learning efforts. In this phase, students explore their learning path and attempt to create and structure their research project. Students (individual and group mode) also get engaged in specific learning activities such as familiarizing with learning strategies and identifying the SRL process.

PBL Phase 3: Refers to individual study and the development of an individual proposal as regards the solution of the ill-structured problem.

PBL Phase 4: Covers teamwork (Forum & Chat) to facilitate the synthesis of a team proposal, based on existent knowledge, for solving the ill-structured problem.

PBL Phase 5: Includes information sharing and the study of the team ill-structured problem solution proposals.

SRL PHASE C: 'Self-Reflection' Phase: While in the third phase, students reflect on the learning activities performed to evaluate their performance. In this phase, students evaluate their research project, their performance and their collaboration. This phase includes self-judgement performed along with a self-evaluation and self-monitoring questionnaire.

PBL Phase 6: Comprises collaboration among learners (Forum & Chat) to provide mutual feedback between 2 teams with regard to the team solution proposals for the ill-structured problem.

PBL Phase 7: Includes learners' reflection on the learning process by virtue of completing self-report questionnaires.

4 Data Analysis

An one-tailed paired t-test was carried out in order to reveal significant differences between the pre-test and post-test results for both Learning Strategies and Collaboration. The one-tailed paired sample t-test used an α level of .05.

Table 1. Results of t-test analysis for learning strategies factors

Factors/indexes		Pre-test		Post-test		Change	
	n	M	SD	M	SD	t	p
Rehearsal	70	4.17	0.63	4.45	0.70	−2.541	.006
Elaboration	70	5.01	0.81	5.34	0.82	−2.962	.002
Organization	70	4.73	0.89	5.07	0.93	−3.390	.000
Critical thinking	70	4.4	0.91	4.26	1.02	1.090	.139
Metacognition	70	4.79	0.50	4.94	0.57	−1.850	.034
Resource management	70	5.00	0.72	4.89	0.70	0.925	.178
Time and study place	70	5.10	0.38	5.07	0.54	0.576	.283
Peer learning	70	4.66	1.07	4.95	1.01	−2.430	.008
Help seeking	70	5.20	0.61	5.04	0.76	1.765	.041

$p < 0.05$, $^{**}p < 0.001$

Table 1 describes the result of the t-test for the Learning Strategies. The analysis of the results reveals a statistically significant difference between the mean number of the pre-test and post-test results for the Rehearsal ($t = -2.541$, $p = .006$), Elaboration ($t = -2.962$, $p = .002$), Organization ($t = -3.390$, $p < .001$.), Metacognition ($t = -1.850$, $p = .034$), Peer Learning ($t = -2.430$, $p = .008$) and Help Seeking factors ($t = 1.765$, $p = .041$). However, the analysis failed to reveal a statistically significant difference between the mean number of the pre-test and post-test results of the students for Critical Thinking ($t = 1.090$, $p = .139$), Resource Management ($t = .925$, $p = .178$) and Time and Study Place ($t = .576$, $p = .283$).

Table 2. Results of t-test analysis for collaboration factors

Factors/indexes	n	Pre-test		Post-test		Change	
		M	SD	M	SD	t	p
TS	70	5.95	0.70	6.52	0.57	−6.144	.000
CoCu	70	5.96	0.62	6.43	0.54	−5.592	.000
TP	70	5.88	0.82	6.35	0.73	−3.926	.000
(CoCo)	70	6.13	0.65	6.56	0.54	−5.266	.000

$p < 0.05$, $^{**}p < 0.001$

Table 2 describes the result of the t-test for the Collaboration factors. The analysis of the results reveals a statistically significant difference between the mean number of pre-test and post-test results for all Collaboration factors of Team Spirit (TS) ($t = -6.144$, $p < .001$), Collaborative Culture (CoCu) ($t = -5.592$, $p < .001$), Trusting Partnership (TP) ($t = -3.926$, $p < .001$) and Collegial Consonance (CoCo) ($t = -5.266$, $p < .001$).

5 Discussion – Suggestions for Further Research

Through the present study the design and implementation of an instructional design workflow based on the combination of PBL and SRL were proposed. A quasi-experimental research throughout a university course was conducted and the data analysis performed by means of self-assessment rubrics, reflecting the learning process. Regarding to the t-test for the Learning Strategies, these findings reveal that the use of the proposed methodology along with the apT^{2}CLE environment indeed tend to enhance learner's skills. Factors such as Organization and Metacognition tend to improve through the use of the SRL methodology implemented in the instructional design workflow. Through the use of SRL Phases, learners have the ability to monitor and regulate their learning process thus achieving organizational and meta-cognitive skills. Referring to the factors of Critical Thinking, Resource Management and Time and Study Place these factors are influenced by the learning environment and are related to the learner's motivation to learn. Therefore, the abilities that the learning environment provides need to be further examined. Regarding to the t-test for the Collaboration Factors, these findings suggest that the use of the proposed methodology along with the apT^{2}CLE environment indeed tend to enhance learner's collaborative skills. Collaboration Factors are closely related to the PBL methodology implemented in the instructional design workflow. Through PBL Phases of the apT^{2}CLE environment, learners developed significant skills in team collaboration as they were required to actively participate in group discussions, propose their own ideas and potential solutions to problems, as well as to evaluate other team members' suggestions. In addition, the flexible communication tools provided by the learning management system, further enhanced the collaboration between team members. These findings suggest that the blended Learning environment, designed along the lines of PBL and SRL, could enhance students' learning strategies and collaborative skills. Furthermore, the overall results reveal learners' active participation in the problem-solving process of the ill-structured problem and the reinforcement of their 21st century skills (collaboration, self-directed learning and critical thinking skills), as depicted in the assessment process. However, the instruments used to assess the indicators examined in the present research need to be further examined.

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Online Learning and Moocs

MOOC Learner Behaviour: Attrition and Retention Analysis and Prediction Based on 11 Courses on the TELESCOPE Platform

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Abstract. Massive Open Online Courses (MOOCs) have become an important online learning tool for educators and learners, but one of the major issues are the high drop-out rates. Recent research suggests not only to identify and support learners at-risk to drop-out but also to differentiate between the group of healthy attrition (intentionally leaving the MOOC) and unhealthy attrition (struggling to complete the MOOC). In this paper, we focus on two research questions: Firstly, can we already identify learners at-risk to drop-out a MOOC in an early stage? Secondly, can we differentiate between the group of healthy attrition and unhealthy attrition? Experimentation with Support Vector Machines based on learners logs from eleven MOOCs on the Telescope platform show first promising results.

Keywords: MOOC · Learning analytics · Attrition · Retention · Dropout prediction

1 Introduction

Information and communication technologies (ICT) have broadly changed the way how we learn and teach. Over the last decades, a movement has emerged which started with *open source* and provided a wide range of tools for the educational sector. This has been followed by *open content* and *open courseware*, the second important pillar of free and open education. Finally, *open online courses,* as the next logical step, have opened formal courses in educational institutions for virtually all potential learners over the globe without any restrictions. Due to the broad interest and need of open education, a big number of learners have enrolled such open online courses and the term Massive Open Online Courses (MOOCs) have been coined [3, 4, 17, 19].

Over the last years, MOOCs raised a lot of attention by learners, educators, educational institutions, and researchers. It was praised as a new form of education for the mass with a high potential. Advantages include free and open education without

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restrictions for everyone, even for the unprivileged and poor ones. It opens up courses from high renowned universities and enables self-guided learning. Very soon, also issues and challenges have been recognized and reported. This includes a big effort in coaching and technical support, and the feeling of isolation and the lack of communication and interaction with peers and tutors. Due to the lack of entry barriers, a great variety of pre-knowledge, computer literacy and expectation caused high drop-out rates, and attrition is reported as one of the major issues [3, 4, 17, 19].

Research in attrition has been an active research field for a very long time. Firstly, it focused on brick-and-mortar institutions and continued in computer-based and online learning. [19] Over the last years, research has increasingly focused on MOOC settings. Research varies from understanding user behavior and uncovering learner groups to models and predictions of learners at-risk to drop-out and leave the MOOCs [1, 2, 5–8].

Seeking a better understanding of the learning processes and learners' behavior, in particular to mitigate attrition issues, a collaborative research between University of Galileo in Guatemala, Curtin University of Technology in Australia, and Graz University of Technology in Austria has been established. Attrition research in MOOC settings and data analysis combined with users' questionnaires revealed three groups of risk for leaving a MOOC, which are (a) the personal learners' factors, (b) factors of the educational institutions and MOOC design, and (c) environmental factors influencing the learners. Narrowing down to the intention of enrolling and accessing a MOOC, questionnaire results indicate that not all enrolled users have as primary goal the completion of a MOOC. Rather, these users enrolled to have access to learning content or to just selectively participate in activities without formal completion. These situations can be described as *healthy attrition,* because the final completion of the course is not indented. In contrary, *unhealthy attrition* subsumes all other situations, in which users want to successfully pass the course but fail for various reasons. Based on these results, the *Attrition Model for Open Learning Environment Setting (AMOES)* has been proposed in order to better understand and differentiate reasons for learners at-risk to drop-out [3, 4].

As follow-up research, we have initiated the European project MOOC maker [18]. As part of this project, we are interested in modeling and predicting user behavior, identifying in an early stage learners at-risk to drop-out, uncovering features which indicate drop-out risks and developing support for learners accordingly. Related work aims at identifying and making early predictions on possible drop-out of learners [5–7]. Complementarily, there are different researches trying to develop strategies to increase learners' engagement by the use of game-based learning, social networks and effective communication within groups [8–11]. Our preliminary results on data of five MOOCs revealed that predicting learners at-risk to drop-out is feasible by taking into account the first half of activities of the MOOC with sufficient accuracy. Also, support vector machines classifier performs better than the K-means approach [15].

In this paper, we focus on two research questions: Firstly, can we already identify learners at-risk to drop-out a MOOC in an early stage? Secondly, can we differentiate between the group of healthy attrition and unhealthy attrition? To this end, logs from eleven MOOCs offered on the Telescope platform are considered [12]. Further related research and more detailed findings and best practices are covered in the MOOC maker deliverable [19]. The remainder of this paper is organized as follows: Sect. 2 gives an overview of the eleven MOOCs and the experimentation setup, followed by data analysis and findings in Sect. 3 and future perspectives in Sect. 4.

2 Experimental Setup

The experiments and studies are based on 11 MOOCs offered by Universidad Galileo on their Telescope platform and are briefly described in Table 1. Each of these MOOCs has a fix 8 weeks duration. In order to obtain a positive grade, learners have to successfully complete weekly activities (in form of quizzes or assignments) and, eventually, a final project and exam. Self-assessment activities are also planned for some MOOCs, but these do not influence learners' final grade. For each MOOCs a log file was created. These files reported each interaction taking place on the platform, and included information as the timestamp of the interaction, the ID of the learners and the particular tool the request referred to. The logs of the MOOCs in our dataset included a total of 21 different tools. However, out of these 21, more than 99% of the total interactions was accounted by 8 tools only, which are listed in Table 2.

Table 1. Description of analyzed MOOCs

MOOC	Target	Completers	Non-completers	Drop-out rate
Android	Students	77	516	87%
Cloud based learning	Professionals, Teachers	123	156	56%
E-learning	Professionals, Teachers	81	164	67%
Community manager	Professionals	320	501	61%
Medical urgencies	No specific target	49	69	58%
Client Attention	Professionals	60	31	34%
Cloud based learning (EDU)	Professionals, Teachers	99	83	45%
Cloud based learning (Tools)	Professionals, Teachers	131	186	59%
Digital interactive TV	Professionals	63	58	47%
E-learning (Tools)	Professionals, Teachers	101	156	60%
User experience	Students	62	127	67%
Combined	**–**	**1166**	**2047**	**58%**

We did the experiment based on the above listed MOOCs (see Table 1) and run 2 classification experiments. As all MOOCs have the same 8 weeks duration, we first analyze the logs on a weekly base and try to classify learners as either likely to complete a MOOC (completers) or at risk of dropping out (non-completers). For this

Table 2. Description of the tools available and used for the analysis

Tool	Description
Assessment	Mostly quizzes. Used to test user knowledge and satisfaction in the MOOC
Assignment	Link to the assignment page (e.g. tasks, projects, etc.)
Course board	Page including the weekly topics of the MOOC
Evaluation	Reports user's grade for each submitted task
File Storage	Link to the documents and resources of the course
Forum	Link to the discussion Forum
Learning content	Whole content of the MOOC. Includes links to files videos, audios, images and any resources used during the course
Peer evaluation	Tool used for the peer review of users

first experiment, we combine data from all MOOCs together and use this as our dataset. We refer to this setting as *completers experiment*.

As second experiment, we attempt to investigate the non-completers class and further categorize the samples within this one as either healthy or unhealthy attrition (see also Sect. 1 and [3, 4]). This second experiment is therefore a multi class classification aimed at finding the reasons that brought non-completers to eventually drop out of the course. In this case, the MOOCs are analyzed individually, without the weekly base split (we use the whole available interactions for each MOOC). We call this setting *attrition experiment*. In the following subsections, we first describe the general approach for features construction and then we specify each setting in details.

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2.1 Preprocessing and Features Creation

As first step, we clean the original log files removing any noisy record. Particularly, we remove interactions with inconsistent timestamp or wrongly tool entry. Interactions recorded with blank user id or tool id are also not considered. The considered learners for each MOOCs are those reported in Table 1. As first step, we sort the interactions of each user chronologically and calculate the sessions (i.e., a list of actions) of every users. Whenever the timespan between two actions is larger than 30 min, we create a new session for the corresponding user. From these sessions we compute the following features for our classification experiment: number of sessions, number of requests, average number of requests per session, total session length, average session length, total timespan within clicks, average timespan within clicks, active days, average requests per total day, average requests per active day. We refer to this first set of features as *session information*. We introduce a second set of features by considering the tool field of the log data. Particularly, from the tools listed in Table 2, we count the number of interactions that refers to each tool. This leads to the following 8 features: assessment, assignment, course board, evaluation, file storage, forum, learning content and peer evaluation. We refer to this second group of features as *request per tool information*.

We want to emphasize that the way we construct all the various set of features is not dependent on any particular domain of the MOOCs. All the features we have defined are, in fact, derived by the timestamp and the tool information.

After creating the features, we randomly split the labeled learner data into a train and a test set, using an 80/20 ratio and a stratified split approach, preserving the class distribution of the overall users' population. As an example, a random stratified split of a dataset consisting of 100 users where 90% are non-completers and 10% are completers (9:1 ratio) with a training-testing splitting of 80/20 will create a training set consisting of 72 non completers and eight completers and a testing set consisting of 18 non-completers and two completers.

After computing the train and test sets, we use for both experiments Support Vector Machines (SVM) for the classification task. SVM has been widely used for classification, with applications such as text classification [22], validation of cancer tissue [23] and user classification in online courses in our previous research [15]. With this classification algorithm, each users is represented as a point in a multidimensional space in the number of features. SVM finds the decision hyperplane that best split the examples (described in terms of different features) in the given number of classes. The best split is the one for which the distance of the closest point of each class to the decision hyperplane is maximized [13, 14]. We train SVM using the train set and predict the class for the examples in the test set. In the training phase, SVM computes the best fitting hyperplane for the examples in the train set. In the fitting phase SVM tries to classify the examples from the test set according to the hyperplane obtained in the training phase.

We evaluated the quality of the obtained classification using F1 score [16], a metric defined as the harmonic mean of precision and recall. Therefore, F1 score is naturally bounded between 0 and 1. A value of 0 indicates that every examples has been misclassified. The higher the F1 score, the more accurate the prediction, with a value of 1 indicating that all the examples have been correctly classified.

2.2 Completers and Attrition Experiments

Our goal in the *completers experiment* is to verify if it is possible to obtain a correct user classification using a limited amount of log data in the analysis. Particularly, we investigate how the accuracy varies by considering featured collected from the first week up to the 8 weeks total length of the MOOCs. Insights in the number of weeks learner behaviour data would indicate potential completers and not-completers is extremely valuable for MOOCs' administrator and tutors. The sooner they can identify at-risk users, the more time they have to reach out to them before the finally leave the course. To this end, for each week we run a separate classification experiment, considering all interactions that took place up to that week. For example, for week 2 we consider all interactions that happened during the first 2 weeks, while for week 5 we use all the interactions registered during the first 5 weeks. The *session information* and the *request per tool information* as described in Sect. 2.1 are therefore created in relation to the total amount of considered weeks.

In the attrition experiment we take a step forward and look at more detail at the non-completers. We attempt to identify subgroups of users within the non-completers using the AMOES model as reference [3, 4]. Particularly, we try to classify the non-completers as healthy or unhealthy attrition (see also Sect. 1). Such classification would help MOOCs' administrators and operators to concentrate on and support only those learners that are willing to complete a course but that, for some particular reasons, are facing problems to do so. In order to do so, we use non-completers answers to a set of surveys that was sent out at the end of each course, to label them as either healthy or unhealthy [17]. For non-completers who did not complete the surveys, no labeling was possible and, therefore, those users are excluded from this experiment. Table 3 summarizes the number of students per MOOC according to their labelling.

Table 3. Number of users according to their label for each MOOC being Completers (C), Healthy (H), Unhealthy (U), Unlabeled (N).

MOOC	Completer	Healthy	Unhealthy	Unlabeled
Android	77	46	38	432
Client attention	60	6	3	22
Cloud-based learning	121	39	15	104
CBL (Edu)	99	16	13	54
CBL (Tools)	131	74	22	90
Community manager	320	78	59	364
Digital interactive TV	63	16	4	38
E-learning	81	27	12	125
E-learning tools	101	20	18	178
Medical urgency	49	6	4	59
User experience	62	28	10	89
Combined	**1164**	**356**	**198**	**1555**

With this setting, the *session information* and the *request per tool information*, are calculated using the whole interactions for each MOOC. Thus, we consider the course's whole duration but run experiments for individual MOOCs and also for the combined data set.

3 Experiment Results and Lessons Learned

The aim of the completers experiment is to verify how the accuracy of the prediction varies when different number of week are considered. Correctly detect users at-risk as soon as possible would allow course instructors to intervene and develop strategies to keep the at-risk users engaged and eventually prevent them from dropping out. The result of this experiment are presented in Table 4. Not surprisingly, we can see that the more weeks are considered the higher is the accuracy to correctly identify completers from the non-completers. From week 6 on, it is possible to obtain an average F1 Score that is higher than 0.8. However, when considering fewer weeks, the predictions exhibit a low accuracy. We believe that the reason for this is the features not providing sufficient information to the SVM, which is unable to correctly discern between completers and not-completers. This is due to too less interactions being available, the fewer weeks are considered. Furthermore, some of the analyzed MOOCs are characterized by the first two/three weeks with low amount of interactions, and not sufficient

Table 4. Results for the eight weeks analyzed in the experience, presenting the three metrics.

Analyzed weeks	Label	Result		
		Precision	Recall	F1 score
Week 1	Completer	0.75	0.60	0.67
	Non completer	0.00	0.00	0.00
	Average	0.62	0.50	0.56
Week 2	Completer	0.70	0.88	0.78
	Non completer	0.00	0.00	0.00
	Average	0.51	0.64	0.57
Week 3	Completer	0.60	0.55	0.57
	Non completer	0.29	0.33	0.31
	Average	0.49	0.47	0.48
Week 4	Completer	0.67	0.90	0.77
	Non completer	0.60	0.25	0.35
	Average	0.64	0.66	0.61
Week 5	Completer	0.76	0.57	0.65
	Non completer	0.44	0.67	0.53
	Average	0.65	0.60	0.61
Week 6	Completer	0.82	1.00	0.90
	Non completer	1.00	0.58	0.74
	Average	0.88	0.86	0.85
Week 7	Completer	0.88	0.91	0.89
	Non completer	0.83	0.77	0.80
	Average	0.86	0.86	0.86
Week 8	Completer	0.92	1.00	0.96
	Non completer	1.00	0.85	0.92
	Average	0.95	0.94	0.94

Table 5. Results from the SVM form five of the MOOCs and a General average for the eleven courses evaluated in the experience.

MOOC	Attrition classes	Precision	Recall	F1 score
Digital interactive TV	Completer	0.92	0.92	**0.92**
	Healthy	0.50	0.67	**0.57**
	Unhealthy	0	0	**0**
	Average	0.79	0.82	**0.81**
E-learning	Completer	1	0.94	**0.97**
	Healthy	0.75	0.60	**0.67**
	Unhealthy	0.25	0.50	**0.33**
	Average	0.88	0.83	**0.85**
E-learning tools	Completer	0.94	0.85	**0.89**
	Healthy	0.43	0.75	**0.55**
	Unhealthy	0.33	0.25	**0.29**
	Average	0.78	0.75	**0.76**
Medical urgency	Completer	1	0.90	**0.95**
	Healthy	0.33	1	**0.50**
	Unhealthy	0	0	**0**
	Average	0.86	0.86	**0.83**
User experience	Completer	1	1	**1**
	Healthy	0.60	0.50	**0.55**
	Unhealthy	0	0	**0**
	Average	0.78	0.75	**0.76**
Global	Completer	0.96	1	**0.98**
	Healthy	0.77	0.67	**0.71**
	Unhealthy	0.20	0.25	**0.22**
	Average	0.83	0.83	**0.83**

for correctly predicting at-risk users. Thus, these MOOCs introduce a certain noise, which subsequently cause a worsening of the overall predictions score. Weekly combined analyses on MOOCs with different structure of the course and organization, can therefore led to low accuracy, especially when only few initial weeks are considered. Increasing the number of analyzed weeks and, therefore, with more available interactions, the accuracy of the predictions increases accordingly.

In the *attrition experiment*, we aim at further classify the non-completers as either healthy or unhealthy. Healthy attrition indicates users enrolled that are however not interested into complete the course. On the other hand, unhealthy attrition is typical of those users that are motivated to complete the course but that are facing problems in doing so. If not supported and scaffolded in time, these users would eventually abandon the course and drop out. Because of this distinction, it is clear that instructors and administrators of MOOCs should focus and be interested on the unhealthy attrition group only. Table 5 reports the results of this experiment for some of the MOOCs. Due to the small number of considered users of most of the MOOCs, some of the results exhibit a low F1 score, which indicates that SVM misclassified most of the learners.

This is the case for the MOOC “Client Attention”, “Digital Interactive TV” and “Medical Urgency”.

Small datasets could introduce difficulties for the classification task performed by SVM. However, the F1 score grows for bigger datasets. Generally, the scores for the completer’s class are always higher than those of both healthy and unhealthy class. We can therefore conclude that users within the class of completers are more similar with each other than users of the class healthy and unhealthy attrition group. In this scenario, it is easier for SVM to distinguish completers from non-completers than to distinguish users within the two subgroups of non-completers. Additionally, it could be possible that the considered features are not good enough to further split the non- completers into the groups of healthy and unhealthy attrition.

4 Conclusions and Future Works

In this paper, we focused based on previous research on two research questions: Firstly, can we already identify learners at-risk to drop-out a MOOC in an early stage? Secondly, can we differentiate between the group of healthy attrition and unhealthy attrition? Experimentation with Support Vector Machine (SVM) based on learner logs from eleven MOOCs on the Telescope platform show first promising results but also leave much room for further improvements.

Correct classification of users into completers and non-completers or in relation to healthy and unhealthy attrition, is harder the fewer amount of data and weeks are analyzed. On the other hand, the earlier it is possible to identify non-completers or users exhibiting unhealthy attrition, the more time tutors or professors have in order to take actions to motivate such users to continue and complete the course. Correct identification of healthy and unhealthy attrition users is a crucial point, because in order to mitigate the overall numbers of dropouts, the focus should be only on the latter group. Healthy attrition users should not be accounted as dropouts, as their final goal is not to successfully complete a course, and therefore to describe them as at-risk, is incorrect.

Identify and construct more valuable features becomes necessary when the amount of information available is generally low or when the amount of analyzed time only include the first few weeks (or any short amount of time). Entry tests or graded assignments could offer more insights and indications of user behaviors already within the first weeks of a MOOC. Analyzing users’ scores, time needed to complete the assignments together with the numbers of wrong or right answers are all factors that would lead to more accurate predictions.

Encouraging social interactions through forum activities and peer evaluations also represent potentially valid ways to increase user engagement and thus mitigate dropouts. Users who constantly engage in the MOOC forum, create discussions, reply to other users’ questions, show high interest in the MOOC and therefore have higher motivations to succeed. Trying to engage a larger number of users to participate in a forum is advisable, but it is not a trivial task and most of the time it is not easily achievable. However, a highly active forum, even if only animated by a few users, could encourage other users as well, who do not actively participate, to at least spending time reading existing discussions and maybe finding answers to their concerns. Although in this way the forum participation would not be improved, it may however bring some improvements and more knowledge to all users. It is important to notice that the MOOC platform and especially the content should be accessible with a special benefit for students with disabilities as a way to increase user engagement through usability and accessibility [20, 21].

As future work, we want to investigate further what are the most important features to predict at an early stage learners at-risk to drop out but also to separate the group of healthy from the group of unhealthy attrition. We also want to research ways to apply generalize models or models for particular types of MOOCs in order to predict learner groups, in particular learners at-risk, for individually designed MOOCs. Final, we want to provide MOOCs' administrators and experts with a dashboard interface to help them individuate at risk users, and provide appropriate follow-up exploiting the results from the SVM classification.

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Blended Learning as a Tool for Work-Life Oriented Master Courses

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Abstract. Masters degree programmes in Finnish Universities of Applied Sciences focus strongly on students' real life work experience and incorporate this in the approach to teaching and learning. Students on these programmes have a higher education degree and at least three years' work experience. Typical course assignments are real development tasks for the students' own employer and classes harness students' diverse experience to enhance the knowledge-base of the course. These courses are proving very popular, but management in practice of such courses (particularly with increasing numbers) is proving problematic. This paper reports findings from a pilot study in which a blended learning approach was used for the delivery of such a course. In this case "blended" refers not just to the mixture of online and face-to-face learning opportunities, but to the mixing of teacher-led instruction with co-creation of knowledge by course participants. Data collected from the study indicate a high degree of satisfaction from both students and staff and point to the particular appropriateness of the technologies used for this interpretation of blended learning. Lack of technology skills is identified as a potential issue requiring further consideration.

Keywords: Online learning · Blended learning · Professional masters' courses

1 Introduction

Many universities now offer Masters degrees which can be studied in modes more convenient to the student, for example, as a part-time degree or as distance learning. Other postgraduate courses aim to integrate or develop students' experiences from and in their professional life. These can provide qualifications directly relevant to students' working practice and may be instrumental in furthering their career.

In Finland, the Universities of Applied Sciences are committed to further developing the concept of integrating work, life and study to provide masters programmes which offer maximum flexibility of high-quality, supported study while at the same time leveraging the students' own work and life skills. This innovative approach to postgraduate study (UAS Masters) is characterised by a requirement for participants to have a minimum of three years' work experience. In addition to providing a personal base of work experience, this requirement ensures students can contribute to shared

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development of knowledge in the student-led, social learning experiences which form part of their course. Typical assignments would involve real development tasks for the students' own employer or own business. Teaching sessions would incorporate interaction among the students as well as direction from a teacher. The term "work-life orientation" is used to indicate the alignment of study with life and working practice combined with the embedding of students' work experience as a vital part of shared knowledge creation within the programme of study.

Such degrees are highly popular, recording high employability benefits and student satisfaction scores above the Finnish average [1]. However, the strong emphasis on work integration means that the majority of students are combining their study with demanding professional lives, in addition to family and other home commitments. It is thus imperative that flexible and accessible methods of study are introduced.

This paper describes a case study in which student feedback was gathered from a "traditional", face-to-face UAS Masters course delivery and analysed to identify some of the major difficulties and barriers to study faced by the participants. This was used as the basis for developing a blended approach, introducing appropriate technology to tackle problems of distance and group working. The paper reports the approach developed and analyses the responses from both teachers and students involved in a pilot of the new course model. We consider the extent to which the use of technology can support the goal of work-life orientation. Further, the discussion is situated in a consideration of the meaning of blended learning in this context and of the aspects of a blended approach appropriate for supporting the vision of UAS Masters.

2 Background

Over the years, divisions between the worlds of academic study and professional life have been gradually breaking down with an increasing understanding of the benefits of closer integration between what were previously often viewed as very distinct communities of practice [2]. Opportunities for postgraduate study have been extended to many professionals, with distance learning programmes facilitating access for students who would otherwise be unable to take part in campus-based education [3]. More recently, novel models which exploit advances in technology (such as Massive Open Online Courses and the Open Educational Resource movement) have further expanded the possibilities for study [4]. Significant challenges still remain, for example, with higher dropout rates observed in distance learning and the resulting need to find more effective pedagogic models which provide the necessary student support [5].

Issues of integration extend beyond the practicalities of time and place of study to the nature of the courses themselves. Professional qualifications and continuing professional development have long been delivered by universities, but more general postgraduate qualifications were often predominantly "academic" in nature. The advent of professional doctorates has changed the emphasis of postgraduate study [6]. While having the same standing as a "traditional" doctorate, they aim to create knowledge that advances professional practice and which relates directly to the student's own experience and work-life. Students' foundation in working practice is thus fundamental to the knowledge creation process of these programmes, with outputs better-suited to the needs of the knowledge economy [7]. There is a growing body of research on appropriate models, structures and ways of connecting to the relevant professions [8]. Distance and part-time routes are common, but can present challenges. While writing a PhD thesis is an individual activity, Wikeley and Muschamp [9] note the "virtual community" of researchers needed to support the research journey. They also express concerns that distance tutors may not always be able to provide the necessary expertise to effectively scaffold learning and help direct research, an issue which is even more problematic when the area of investigation is based in the student's working practice. Butcher and Sieminski [10] view the solution as being a support system which is highly structured yet flexible, although establishing what this means in practice is unclear.

At the Masters level, the move to work-life integration presents similar, and possibly greater, challenges. Issues with tutor expertise and the need to provide effective direction for individual students contributing many different professional experiences remains. However, it is magnified by the larger numbers of students involved and the need to coordinate social creation of knowledge contributed by different students. The virtual community aspect is also extremely important, with sharing of experience and group assignments forming an integral part of the approach. New models are needed to support this [11]. One approach to delivering Masters level education which is now widely used is blended learning. This is viewed by some authors as providing an appropriate framework for providing a balanced learning experience, fostering the development of a community of practice and promoting educational dialogue which can transform professional practice [12].

Despite widespread use of the term "blended learning" there is lack of consistency in the way it is applied [13, 14]. Most commonly, it refers to the integrated combination of traditional learning with web-based, on-line approaches, with "traditional learning" interpreted as face-to-face meetings with instructors in a single, physical lecture theatre or seminar room. Oliver and Trigwell [15] have questioned the meaningfulness of the term "blended learning" arguing, firstly, that it is generally not applied to learning but to instruction and, secondly, that there is no satisfactory idea of what is being blended. Noting that students' experience of the instructional opportunities offered may be very different from that intended by the instructor, they state: "actual blended learning would involve students learning through experiencing variation in aspects of what it is they are studying (their object of study)" [1, p. 22].

In this study we use a case study approach to investigate a blended learning format in which the blending refers not just to the introduction of learning technology but also to the blending of professional experience with "traditional" teaching as a fundamental part of the knowledge creation process. The study first examines data to investigate the perceptions and problems encountered with students studying in a traditional mode and then compares this to their experience when the new format is introduced.

3 Case Study

3.1 Research Method and Data Collection

In this research paper a case study approach is used. Yin [16, p. 13] defines a case study as an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." According to Yin [16] case study research is appropriate to answer the questions "how" and "why", which aim to explain causal connections or a series of events that happened during a longer period. It is also appropriate to answer the explorative "what" question and evaluate and describe the research. So, the initial task is to clarify rigorously the nature of the study questions. The collected data can be either qualitative or quantitative [17].

The current research followed a methodology incorporating four stages according to Yin's [16] recommendation: design the case study, conduct the case study, analyze the case study evidence, and develop the conclusions, recommendations and implications. The underlying case study of blended learning relies on multiple data sources including online surveys, interviews and observation.

3.2 Design of the Case Study

The case study of this research paper is based on a Masters level course in Innovative Entrepreneurship and SME Management. The existing, traditional implementation of the course included three slots of lectures and written assignments. One teaching day consists of eight hours of lectures. The Masters programme is organized in a co-operating network of three universities of applied sciences (UAS1, UAS2 and UAS3) located approximately 100 km from each other. That means that studies in the network require a lot of traveling for face-to-face sessions. The number of students has increased from year to year and the current size of the overall cohort is 80 students.

Studies were started in the traditional format, with students travelling to their teaching sessions. After the first study day feedback was collected through an online survey. The online student questionnaire was made available through social media (Facebook) to all 31 participants from UAS1. All of them responded to it, with ten giving additional free-form comments when completing the survey. The comments shown below are typical of those received relating to students' opinions about the course and about the way of working when the course was delivered in traditional mode. Firstly, there were practical issues with travel and with being present at the face-to-face sessions:

> "The day was ok. Travel is too long (140 km) and time-consuming" (Student C).

Many students faced similar journeys to Student C and the overheads of time, cost and inconvenience are negative factors for the teaching day. The second issue involved the growing number of participants and the way this affected the teaching methods of the course. Many students commented on this:

> "The subject is interesting, but team work with so a big group is not reasonable regarding the use of time" (Student A).

The size of the group increased the time needed for student presentations and discussion which in turn squeezed the time available for other activities:

> "I agree that the subject is interesting. However, I would have liked to hear more of the teacher's thoughts and theories. The presentations of group works (13 groups, each with 5-6 persons) took too big a part of the teaching day although those conversations included a lot of different points of view" (Student B).

> "I agree with the Student B: the lectures shrank to nothing, and as important and interesting as the talks are, in my opinion, they should not be the main role and last the whole day. We were just too many punters. And the same issue may be repeated in the coming occasions when many students want to have a full discussion and comment on all of it. This did not work with such big group" (Student D).

Some students raised the problem that participants did not understand that their behaviour needed to be different in the big student group. According to them also students should have better situational awareness:

> "In adult education it has always been great that it is expected to hear the experience and views of the various sectors in the form of discussions. Now, however, the participants are about 80 adult students. I supposed that they would have understood that in such a big group there is no space to highlight their personal opinions and especially on several occasions. I would have expected that the students understand that a large group is not any discussion forum. Also, lectures could have been tighter in sharing of speeches. With regret I have to say that this time I didn't get any new ideas or learn anything" (Student E).

> "Subject was interesting, but the discussions could have been cut off earlier so we could go forward" (Student F).

Thus the problems with the way of working were not just an inconvenience but presented a direct barrier to learning. When asked about these issues, some of the students themselves started to point to different possible ways of working:

> "Wonderful if we could have blended learning!" (Student F).

> "We would like to have online lectures" (Student C).

Based on the survey, we can conclude that traditional teaching arrangements were unsatisfactory. There were a lot of problems with practical arrangements and difficulties in interaction and in consideration of work-life orientation. There was a strong need to develop a new kind teaching approach in order to combine the requirements of work-life orientation and the challenges of the Masters courses such as the increasing number of students, problems with integration of working life and study, and the long distances between students and universities.

3.3 Implementation of the Blended Learning

The implementation of the pilot course included pre-planning, development and conducting the course. All the activities were made in close collaboration with students and there was a good deal of interaction between teachers and students. Student and teacher interviews and observation of the processes provided essential data to the following in-depth case analysis.

Students were allocated to four separate groups in different geographical locations. Some of them elected to work “home alone” based on their own life commitments, joining the group virtually by means of technology. Adequate facilities such as computer classrooms, headphones and support for small-group work were planned and booked. It was crucial to inform students about all the arrangements and to prepare them for the new ways of working, including practical issues such as support for technology installation and use.

In pre-planning two different perspectives were taken into account: pedagogical and technological. Firstly, from the pedagogical perspective the learning objectives, components and tasks of study days were defined. Regarding the orientation of the Masters studies, the integration of the students’ own work experience was planned. Secondly, the phasing of the course and study days were defined. Thirdly learning tasks were planned and selected based on the following issues: individual or group assignments; virtual or face-to-face groups; implementation task instruments; assessment tools; administration and collection of feedback.

The technological perspective involved the planning and implementation of the course including aspects such as lectures, tasks and scheduling. Checking and testing the technology that would be used was a crucial part in the planning process. In addition, routes for student guidance were pre-planned and technological support was put in place. Exceptional situations were identified and managed and back-up plans were made to address potentially problematic scenarios. Testing opportunities were arranged for students during the week before the teaching started.

During the conducting of the course, moderation was one of the key issues and played a pivotal role in the success of the course. Moderator´s main tasks are to ensure that participants will receive help with technical problems if needed and all are able to participate. Typically, a moderator’s skill areas are technological, pedagogical or both of those. At the start of this case study each moderator was a co-teacher of the course. However, during the course, students took more responsibilities and some of them acted as moderators. In addition, tools to support remote participation were used during the delivery of the course. These included shared lectures, presentations and desktops; gathering opinions, voting, oral and written interaction; and the use of chat and group work tools to combine both virtual and face-to-face participation.

4 Analysis

After the teaching day, a web survey was distributed to the whole group (80 students) and 70 students responded. Of these, 97.2% (n = 68) felt that the course was excellent, with a further 2.8% (n = 2) of students rating it as good. None of them evaluated it as satisfactory or poor. In addition, students’ opinions were collected in a Facebook group. These comments indicate that students were very satisfied with the pedagogical aspects of the course and with their learning results.

Data gathered from the interviews, student feedback and observation indicated four main areas of strength in the blended learning version of the course: work-life orientation; learning results; student and teacher satisfaction and time and cost-effectiveness.

Below we discuss some of the evidence given in support of improvement of these four aspects.

Good learning results indicate that the course has been successful in the integration of theoretical knowledge and work-life experiences. In addition, in the blended learning course students worked in smaller teams in order to have more opportunity for discussion. As well as interaction with their team, the format enabled students to engage in increased interaction with the teacher. This was supported by the use of chat tools. In order to share and assimilate work-life knowledge students need teams (of an appropriate size) and effective means to support interaction. In order to get good learning results in big blended learning group careful pre-planning and good management of knowledge sharing situations is required. Students' comments indicate that all of these aspects came together to provide excellent interaction opportunities and learning through sharing if work-life experiences. They also raise the interesting issue that the teacher's role is still vital in this and that teachers' effectiveness in working with the tools is instrumental in the success of the approach. For example, one of the students described how effective their teacher had been in harnessing the potential of the chat tool within the pilot study course:

> "I was so satisfied with the teacher's ability to collect opinions by the chat tool and make summaries about those" (Student B).

The blended learning method enables both learning in teams and individual learning. The following student's comment demonstrates that well:

> "I learned better because I was able to stay home alone. For me it was better to concentrate in that way" (Student A).

This quote raises the issue that, as well as solving practical constraints such as travel difficulties, an approach which allows students to self-select a method of studying can support them in choosing ways of working that suit them best. Self-direction is an important aspect of learning, and students who are able to reflect on how they learn best and make choices appropriate to their needs have been shown to learn more effectively [18]. Recognising the environment in which personal learning is maximized is part of self-regulated learning and the blended learning pilot study is demonstrating that students are using the opportunity effectively.

Student satisfaction with the course was better in comparison to the previous feedback surveys regarding the same course taught in traditional mode. Increased satisfaction applies also to the teacher who noted in the teacher's interview that he was especially satisfied with the management of the big group. According to him, both satisfaction level and learning results of the course were better than those observed for the traditional course methods.

It was clearly demonstrated that the arrangements of the course were more reasonable regarding time and travel expenses. Many of the students emphasized comfort arrangements such as shorter driving distances and time and cost savings. For some students with families it was important to have an option to stay home to study if necessary.

Although the blended learning format was preferred overwhelmingly by the students, the data collected did indicate some weaknesses in the blended learning implementation of the pilot study. This live run of the course allowed some technological limitations to be identified. For example, the use of a conference microphone in group presentation caused some audibility problems. Such technology-based problems are useful to uncover and can be addressed for future presentations of the course. In addition, it became apparent that some of the student had inadequate IT skills to make full use of the opportunities offered. Although technology support was provided, some students needed greater help and more confidence to participate fully.

A comparision of the blended learning course and traditional course is presented in Fig. 1 below.

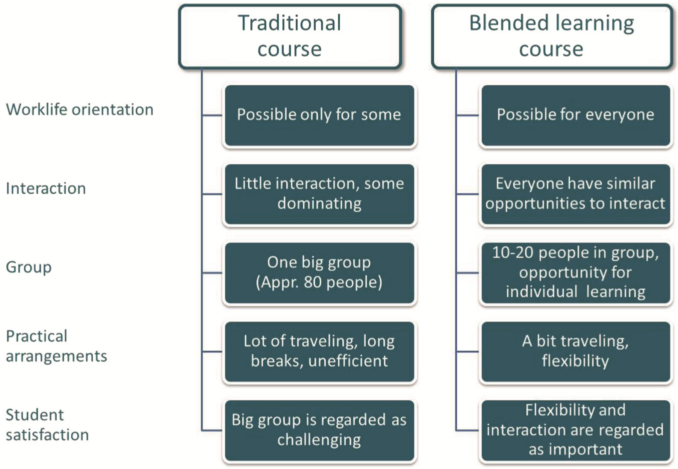

Fig. 1. Comparison of traditional and blended course

Overall, the reception was extremely positive from both staff and students and the problematic issues identified were mainly small ones which could be easily fixed for future delivery of the course.

5 Discussion

Using learning technologies in different ways can alter what Oliver and Trigwell [15] refer to as the "learning space": the framework creating the potential for student learning. While students may experience the dimensions of this space in different ways, it is a mark of good teaching to be able to configure the space in a way that maximises learning. Blended methods of teaching may increase such possibilities. Further, a diversity of possibilities within the learning space allows students to choose options which best suit their individual needs and support the ways in which they know they learn most effectively. Hence both good teaching and self-directed learning can develop within the blended learning space.

Blended learning is sometimes used to refer simply to a (rather vague) combination of online and face-to-face teaching. However, the approach embodied in the UAS Masters programmes introduces a very different dimension of blending, that is, the fundamental integration with lived, practical experience. Further, it is not a single such experience that is represented but as many different perspectives as there are students on the course. Thus the variation observed and knowledge created is new and different each time. This has major learning benefits and casts students as co-creators of knowledge. However, it can be difficult to manage in the classroom, particularly as the students are necessarily involved in working lives and physical attendance becomes more difficult for some. The approach of the pilot study is particularly well-suited to supporting this type of blending and was much appreciated by the students. The practicalities of dealing with a large group can also be addressed by effective use of pedagogic and technological means.

The challenges of good teaching within this space still remain. Using different technologies does not guarantee increased learning, just as students' background of work experience does not necessarily contribute to learning. It is possible that, without careful direction and organisation, the multiplicity of perspectives and situations could result in confusion and a less conducive learning space. The difficulties encountered in the traditional mode of delivery indicate that more is not always better. However, the feedback from the pilot study shows that the combination of pedagogy and technology (breaking up the group, supporting by online communication tools) was felt by the students to be effective for their learning.

One interesting aspect emerging from the pilot study is the central importance of the teacher and the teacher's skills in effectively managing the learning space and the learning opportunities. It has sometimes been suggested that online learning and blended learning can replace or reduce the need for effective teaching. However, some of the aspects which made the course most beneficial to learners were related to their teachers' ability to guide them in contextualizing and making sense of the diversity of work-life experiences presented. This therefore indicates the need for teachers to be skilled and confident both in the presentation of their subject and in ways to use the learning technologies to support this. The teacher in the pilot study was noted by the students as being very effective in this, however, it has been noted elsewhere that many teachers are currently worried about their ability to use learning technologies effectively and are resistant to trying new approaches [19]. This indicates an area which may need to be addressed for expansion of the approach. In addition, it was apparent from the pilot study that some students did not have the necessary technical skills, even though support was provided. Again, this is an area which needs further consideration for future use of the blended approach.

The case study presented here represents a first step in the exploration of this space and appropriate ways to configure it. The use of learning technology is one aspect of the space of learning provided by the course, but the work-life integration is also significant. By focusing on the reflections of the students we learn more about their subjective experience of the blended learning approach (in all its facets) and the ways in which this can be altered to improve the space of learning for future participants.

Based on the implementation and feedback of the pilot course some practical implications and teaching guidelines related to the blended learning are presented. It is obvious that traditional teaching methods are not adequate due to the students´ requirements regarding the online studies. As well, we must take into account that the work-life orientation is an integral part of the master studies.

The results of this study have some implications for the teaching of master studies, including guidelines for efficient blended teaching. In addition to the practical value for the master studies, the experience can be utilised in other communication situations among teachers and students.

Firstly, within the context of changing teaching process, teacher´s motivation and attitudes toward the new teaching methods are significant issues. Therefore, educational institutions need to encourage teachers to the change. In addition, it is particularly important that teachers can get support with their development processes.

Secondly, both the pedagogical and the technological pre-planning are crucial in the blended learning process. Based on this study, it can be recommended that the management of the education institutions enables this for teachers, because adequate time-scales and suitable workloads are essential factors in the pre-planning process.

Thirdly, based on this study, it can be seen that both the pedagogical and the technological support during the teaching process, especially in the beginning, were key elements in successful implementation of the blended learning courses.

Finally, in order to sustain the value of the blended learning methods, they should be assessed and new methods developed continuously.

6 Conclusions

Overall the blended approach was a success, being well-received and highly-rated by all students. Not only were student satisfaction levels higher, but staff satisfaction was also increased. Both staff and students displayed a very positive attitude, showing high levels of motivation and a willingness to experiment and develop new ways of working. The time spent in advance planning was effective in developing good pedagogic and technical strategies, combining the two for effective delivery and improved learning opportunities. The implementation was generally effective, with thorough testing supporting delivery of a high quality course even for the pilot study. There were some technical issues noted but generally these were of a minor nature and solutions could be found. Different forms of feedback gathered throughout the course allowed students' views to be gathered and to feed in to the continued development and the on-going learning experience of the course members.

Blended learning in the case of this study has meant blending not just online and face-to-face teaching. It also involves the blending of teacher-led learning opportunities with the social creation of knowledge through sharing of work-life experience by course participants. The format of the pilot course appears to be particularly effective for this type of learning. The participants are all professional with a guaranteed level of workplace experience. They bring to the course both a level of knowledge and a maturity of learning which makes them ideally placed to explore the opportunities of the learning space provided and exploit them to best effect for their own learning needs.

This study also indicates several challenges which point to the need for further investigation. Firstly, in terms of technology, many students and staff are still apprehensive about innovative uses of learning technologies. This needs to be addressed in order to make such courses accessible to all students and for staff to be confident they have the skills needed to provide a good teaching in the space. Secondly, the continuing importance of effective teachers emerged as a key point. This indicates the need to further explore new pedagogic approaches which can make best use of the technological approaches on offer.

In the research process, the perspective of practical benefits was strongly present. In future research, the theoretical perspective may have a deeper role in the blended learning process. It would be interesting to examine the methods by which better work-life orientation will be achieved.

This research will hopefully increase awareness of the significance of blended learning in work-life oriented teaching process. The development of new methods in order to confront changing learning environment helps to create and sustain efficient teaching processes. The authors hope that the identification of the role of blended learning as a tool of work-life oriented teaching can provide development possibilities for educational institutions.

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A Survey of Learner and Researcher Related Challenges in E-learning Recommender Systems

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Abstract. In recent years, recommender systems have been widely used to support online learning in educational institutions. However, there are still some challenges experienced by learners and researchers hindering the full implementation and utilization of recommender systems in e-learning environments. In this paper, we review the main learner and researcher related challenges of e-learning recommender systems. This was achieved by carrying out a systematic literature review of relevant journal papers on e-learning recommender systems with a view to identifying and classifying the challenges as either learner or researcher challenges. The results of the survey reveal that successful implementation and utilization of e-learning recommender systems is hindered by some challenges categorized in this review as learner and researcher challenges. The paper also identifies some possible solutions from different studies for alleviating the challenges as well as the limitations. The implications of this study will be vital in assisting learners and educational institutions utilize recommender systems to support online teaching and learning.

Keywords: E-learning · Recommender systems · Learner challenges · Researcher challenges

1 Introduction

E-learning plays an important role in supporting teaching and learning in educational institutions. Manouselis et al. [1] points out that e-learning is an application domain that covers technologies that support all forms of teaching and learning activities. Many learners today prefer e-learning as an alternative new approach since they can take their learning anytime, anywhere and at any place [2, 3]. It is for this reason that it is gaining acceptance in many educational institutions as an innovative approach to teaching and learning supported by information and communication technologies [4]. However, with the explosion of the World Wide Web coupled with large numbers of online learning materials, learners are experiencing difficulty retrieving relevant learning materials in a large space of possible options [5, 6]. Tang and McCalla [7] point out that in e-learning environments, learners are overwhelmed by information overload which is difficult to handle. As a result, learners get confused in their attempt to choose the appropriate

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learning materials especially when the number of choices increases. To overcome this problem, recommender systems provide an effective solution that can aid learners to find useful learning materials that meet their learning needs in e-learning environments. Recommender systems are software tools which recommend the most suitable items to particular user by predicting the user's preference on the item [8]. An example of an e-learning application using recommender system to suggest relevant courses to learners is Coursera[1]. There are various techniques used for automatic recommendation of items to users namely collaborative filtering, content-based, knowledge-based, context-aware based and hybrid filtering among others [1, 9]. Collaborative filtering recommend items to the target user similar to those liked by other users with similar preferences [10]. On the other hand, content-based recommender systems recommend items that are similar in content features to the ones liked by the user in the past [11]. In knowledge-based recommendation technique, domain knowledge is used to make inference about the user needs and preferences [12, 13]. E-learning recommender systems play an important educational role in supporting online learning by providing personalized recommendations of learning resources to the learner for better achievement of the learning goals [14, 15].

Although recommender systems have been widely used in e-learning environments in the last few years, they still face some challenges hindering its full implementation and utilization by the learners, teachers, and researchers. In this paper, we review the learner and researcher related challenges facing the implementation and utilization of e-learning recommender systems in educational institutions. Further, we identify the possible solutions to alleviate these challenges.

Though previous studies have addressed some of the issues affecting recommender systems in various domains, there is still a gap in carrying out specific review on learner and researcher related challenges of recommender systems in e-learning environments. Most previous studies focused on general challenges in the area of e-learning recommender systems. In this work, we focus on learner and researcher related challenges of e-learning recommender systems. Our work makes two major contributions that distinguish it from previous studies:

- First, we review and classify the main learner and researcher related challenges of e-learning recommender systems.
- Secondly, based on the review of the challenges, we identify possible solutions for alleviating those challenges and highlight the limitations of the existing solutions.

The rest of this paper is organized as follows: Sect. 2 presents the related work; Sect. 3 explains the methodology used in this study while Sect. 4 presents the results, discussion and limitations. The paper concludes in Sect. 5.

[1] https://www.coursera.org/.

2 Related Work

2.1 E-learning Recommender Systems

A number of studies on recommender systems for e-learning have been carried out in the last few years. E-learning recommender systems differ from general recommender systems in a number of ways. For example, Garcia-Martinez and Hamou-Lhadj [16] points out that the context of recommendations in e-learning recommender systems is pedagogically related. Such pedagogical contexts include the learners learning style, background knowledge, pre-requisites and instructional design. The main benefit of e-learning recommender systems is to help the learners reach the desired pedagogical goals through improving learner performance, social learning enhancement as well as increase learner's motivation. Moreover, e-learning recommender systems help the learners to find useful and relevant learning resources for purposes of improving the achievement of the learning goals and development of competences in less time [15, 17]. Tang et al. [18] notes that a good educational recommender system should make use of additional contextual information instead of pure ratings to determine the similarity and preferences of learners. Such additional pedagogical information includes learning style, study level, knowledge level, skills and competence level among others. Klašnja-Milićević et al. [19] describe a recommender system which can automatically adapt to the interests and knowledge level of learners. Their system is used to suggest online learning activities to learners based on their learning style, knowledge and preferences. On the other hand, Jovanović et al. [20] used several kinds of learning related ontologies such as user modeling ontology and content structuring ontology in order to capture the information specific context of learning objects, learning designs as well as personalization. In our previous work [21], we used ontology to represent knowledge about the learner's learning style and knowledge level in a recommender system for recommending learning resources to learners in an e-learning environment. The experimental results of our hybrid system showed improvement in accuracy and performance. Most personalized e-learning recommender systems use ontologies for semantic knowledge representation, domain conceptualization and automatic knowledge acquisition [22]. Personalization of learner profile through the use of ontology makes the recommendations more tailored to the target learner preferences. More recently, Tarus et al. [13] carried out a comprehensive review of knowledge-based recommendation in e-learning domain and found out that ontology is widely used in e-learning recommender systems for knowledge representation.

2.2 Challenges of Recommender Systems

Previous studies show that implementation of recommender systems still face a number of challenges. As a result, researchers have carried out studies in the last few years with a view to identifying and addressing these challenges. For instance, Verbert et al. [23] presented a survey as well as future challenges of context-aware recommender systems for Technology Enhanced Learning (TEL). Among the challenges identified include context-acquisition, presentation challenges and evaluation challenges. Similarly, Tarus et al. [21] proposed a recommendation approach for learning resources by combining collaborative filtering, ontology and sequential pattern mining and suggested solutions for alleviating the cold-start and sparsity problems by using ontology domain knowledge and learner's sequential learning pattern in the absence of sufficient ratings. On the other hand, Mika [24] investigated on challenges of recommender systems in the area of nutrition and further discussed ways to deal with those challenges. He et al. [25] analyzed the existing interactive recommender systems and presented the future research challenges facing such interactive recommender systems. The challenges identified include cold-start and diversity problems. Khusro et al. [26] investigated issues and research opportunities facing recommender systems. Among the challenges they focused on include latency, data sparsity, grey sheep and cold-start problem.

Our work focuses on review of learner and researcher related challenges in the field of e-learning recommender systems.

3 Method

This review was guided by the methodological guidelines recommended by Kitchenham and Charters [27] for carrying out systematic literature reviews in the field of software engineering. The relevant papers were retrieved by searching the digital databases for research papers which included Science direct, Engineering Index (EI), ACM, IEEE Xplore, Springer and Web of Science. In order to search the digital databases exhaustively, Boolean operators "OR" and "AND" were used to combine the various search strings. The inclusion criteria applied to the retrieved papers include: (i) papers on recommender systems whose application domain is e-learning (ii) papers that investigate or discuss one or more learner and researcher challenges of e-learning recommender systems. Only peer reviewed journal papers were considered in this work due to the quality and reliability of their results.

After retrieval of the publications, the authors reviewed the papers and selected the relevant publications that met the inclusion criteria. The authors analyzed the selected papers qualitatively using content analysis technique. The information of interest that was extracted during review and analysis of the selected papers included the author(s); the recommendation challenges and solutions; and the affected recommendation technique(s). The challenges were identified in the selected papers and categorized as either learner or researcher related challenges. Those challenges that affect learners who use e-learning recommender systems were categorized as learner challenges. Similarly, the challenges that limited the researchers from evaluating recommender systems successfully were classified as researcher challenges. Figure 1 shows our classification model of the learner and researcher related challenges of e-learning recommender systems.

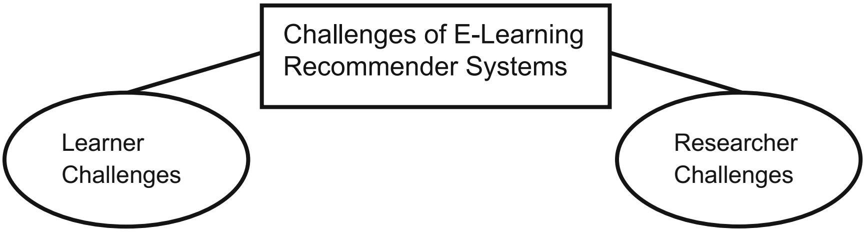

Fig. 1. Categories of challenges of e-learning recommender systems.

4 Results and Discussion

In this section, we present the results and discussion of our review of learner and researcher related challenges of e-learning recommender systems alongside the possible solutions for alleviating them. In presenting the review results, we focus on the name of challenge, the affected recommendation technique, and the relevant references (Tables 1 and 2). Some challenges affect more than recommendation technique. For clarity, the results are grouped into two categories namely learner related (Table 1) and researcher related (Table 2) challenges. Tables 1 and 2 presents the classification of the challenges into the two categories namely learner and researcher related challenges respectively.

Table 1. Learner related challenges of e-learning recommender systems

Challenge	Affected recommendation technique(s)	References
Privacy issue	All e-learning recommender systems	Verbert et al. [23], Khusro et al. [26], Su and Khoshgoftaar [28], Garcia-Martinez and Hamou-Lhadj [16], He et al. [25]
Trust in recommendations	Collaborative filtering & Content-based	Jannach et al. [29], Martinez-cruz et al. [30], Eirinaki et al. [31]
Motivation to rate items	Collaborative filtering	Ekstrand et al. [32], Salehi and Kamalabadi [33]
Changing learner characteristics	Collaborative filtering & content-based	Khusro et al. [26], Tarus et al. [21], Verbert et al. [23]

Table 2. Researcher related challenges of e-learning recommender systems

Challenge	Affected recommendation technique(s)	References
Evaluation challenges	All e-learning recommender systems	He et al. [25], Verbert et al. [34], Verbert et al. [23], Erdt et al. [35], Tarus et al. [21]
Dataset sharing challenges	All e-learning recommender systems	Verbert et al. [34], Verbert et al. [23], Erdt et al. [35], Tarus et al. [13]

4.1 Learner Related Challenges and Solutions of E-learning Recommender Systems

The first category of challenges reviewed in this work is learner related challenges of e-learning recommender systems. Table 1 illustrates the learner related challenges of e-learning recommender systems identified in this review. The main learner related challenges include: *privacy issues*; *trust issues*; *motivation to rate items*; and *changing learner characteristics.*

(a) Privacy issues: Concerns on privacy issues hinders learners from providing relevant data necessary for enhancing the performance of recommender systems. Ricci et al. [8] points out that to generate good quality recommendations, e-learning recommender systems need to collect as much learner information as possible. However, learners may feel that their privacy is likely to be comprised. Similarly, user data in unsecure recommender systems is likely to be compromised and misused in some instances [26, 28]. Generally, recommender systems require the learners' demographic and ratings information in order to provide personalized and accurate recommendations.

A good e-learning recommender system for learning materials should guarantee privacy and security of learners' personal data stored in the recommender system. This can be achieved by using privacy preserving algorithms that preserve learners' identity [23, 25, 26, 28].

(b) Lack of trust in recommendations: Lack of trust in recommendations by learners is another challenge of e-learning recommender systems. Most e-learning recommender systems do not explain to the learners how the recommended items were selected, hence learners may have little trust in the recommendations.

To tackle this challenge, recommender systems should provide explanations alongside the recommendations. Explanations should provide information as to why one item was preferred over another as well as build trust in the learners concerning recommendations to reduce the uncertainty about the quality of recommendations [29]. Additionally, trust models can be incorporated in e-learning recommender systems [30, 31].

(c) Motivation to rate items: Most learners are reluctant to rate learning materials in situations where explicit ratings are required by the recommender system. This is partly because they lack the motivation and awareness on the importance of rating learning materials. Collaborative filtering which is the commonly used recommendation technique requires ratings in order to generate recommendations [30, 36]. Few ratings or lack of it in an e-learning recommender system limits the recommender from personalizing and providing accurate recommendations to the learner.

To alleviate this problem, e-learning recommender systems should be designed to acquire ratings both explicitly and implicitly. Implicit ratings are acquired when the learner navigates, reads or downloads learning resources. Other recommender systems such as content-based generate recommendations based on content similarity while knowledge-based recommender systems use knowledge structures such as ontologies to represent knowledge about the learners and learning materials [21]. These recommendation approaches that do not use ratings can be hybridized with collaborative filtering technique. Other solutions include using hybrid-based filtering by incorporating learner's sequential learning patterns into the recommendation process which can predict learning resource's for the target learner without relying on ratings [21, 33, 37].

(d) Changing learner characteristics: Learner characteristics such as study level, knowledge level, skills and learner context change over time and these changes influence the learner preferences [21]. Most recommender systems such as collaborative filtering and content-based do not consider the changing learner characteristics in their recommendation processes. This may result in recommendation of learning materials that are not personalized to the target learner.

To overcome the challenge of changing learner characteristics, recommendation techniques that integrate additional learner's information such as knowledge level, study level, learning styles, and learner context among others should be employed by developers of e-learning recommender systems [21, 23, 26].

4.2 Researcher Related Challenges and Solutions of E-learning Recommender Systems

The second category of the reviewed challenges of e-learning recommender systems is the researcher related challenges. Table 2 shows the researcher related challenges of e-learning recommender systems. These challenges include *evaluation challenges* and *dataset sharing challenges*.

(a) Evaluation challenges: Despite the success in research on e-learning recommender systems, there is still scarcity of public datasets for evaluating e-learning recommender systems [21, 23, 35]. Without public datasets for e-learning recommender systems, it becomes difficult to evaluate and compare results of one study with other previous studies.

As a remedy to scarcity of public datasets for e-learning recommender systems, researchers have suggested that real world data can be collected and used for evaluation at the initial stages [34]. Secondly, public datasets from other domains such as movielens dataset can be used by researchers for initial testing and evaluation. However, a real public e-learning dataset will be a necessity for final verification of evaluation results and comparison of performance [13, 35].

(b) Dataset sharing challenges: Data sharing is another challenge facing e-learning recommender systems researchers. Although a number of researchers and relevant organizations have managed to collect e-learning recommender systems data for evaluation purposes overtime, most of these datasets still remain private mainly due to privacy issues, hence hindering progress in research on e-learning recommender systems [13, 34].

To overcome this challenge, researchers and relevant institutions need to work on strategies for dataset sharing to facilitate standardization in evaluation of e-learning recommender systems. This can be achieved by addressing legal and privacy issues pertaining to dataset sharing [34, 35].

4.3 Limitations

The major limitation of this study is that our work focused only on the major learner and researcher related challenges facing e-learning recommender systems. However, there is possibility that there are other challenges that previous research studies have not brought to the fore. In addition, technological challenges of e-learning recommender systems were not reviewed in this study. Similarly, challenges of more recent recommendation techniques such as trust-aware, group-based, social-network and ontology-based recommender systems have not been explored widely. Therefore, there is need for further research to investigate the challenges and propose solutions associated with these new recommendation techniques in the context of e-learning. Furthermore, challenges of e-learning recommender systems relating to pedagogy have not been investigated widely.

Secondly, the reviewed previous research studies revealed that the optimum solutions to the challenges have not been achieved fully. Therefore, more research studies need to be carried out with a view to finding more optimum solutions for eliminating completely these challenges.

5 Conclusion and Future Work

In the last few years, e-learning recommender systems have played an important role in assisting online learners to overcome information overload problem and easily access relevant learning materials. However, the learners and researchers still face some challenges that hinder successful utilization of e-learning recommender systems. In this paper, we reviewed the learner and researcher related challenges facing the implementation and utilization of recommender systems in e-learning. The paper further identifies solutions for addressing each of the challenges. Successful utilization and improvement of e-learning recommender systems can be achieved if the identified learner and researcher related challenges can be addressed. It is our hope that these findings will provide beneficial literature and solutions for researchers and stakeholders in the field of recommender systems for e-learning.

Future work will focus on addressing the challenges associated with more recent recommendation methods such as ontology-based, trust-aware based, group based and social network based recommendation in e-learning environments.

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Problem-Based Learning in Language Instruction: A Collaboration and Language Learning Skills Framework in a CSCL Environment

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Abstract. Research has shown problem-based learning (PBL) to be an effective learning method in many ways. Although PBL learning has been studied extensively and a number of papers have discussed the merits of implementing PBL in educational environments, greater emphasis should be given on how it can be adapted to teach language effectively in secondary education. To make language learning skills more effective, an educational scenario was prepared based on the principles of a PBL model and the Jigsaw II collaborative strategy in a Computer Supported Collaborative Learning (CSCL) environment (Moodle). This educational scenario was designed and implemented so as to bolster collaboration and to enhance the language learning skills for high school students. There was both a quantitative and a qualitative analysis of wiki texts as well as chat and forum messages exchanged by the students. The results revealed that students developed collaboration and language learning skills to a great extent as a result of their participation in collaborative tasks.

Keywords: Problem based learning (PBL) · Collaboration skills · Language learning skills · Secondary education · CSCL · Moodle

1 Introduction

Research has shown that problem-based learning (PBL) is beneficial in many respects [9, 10]. Although a number of papers have discussed the advantages of implementing PBL in secondary education [2, 22, 26], there is a need for further research on how it can be used effectively in language learning. The acquisition of language skills is arguably more effective through web-based instruction and computer-meditated communication. Several researchers believe that in this way, learners connect in a better way with authentic language learning environments and become more experienced in collaborative learning and social interaction which are associated with the improvement of language learning skills [11, 16].

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Since PBL supports authentic learning, motivates students to investigate various subject areas and increases the social aspects of language learning [4, 7, 14, 23], it is obvious that it could be the proper theoretical framework for the creation of an authentic language learning environment. Furthermore, PBL fosters the development of self-directed learning, critical thinking, problem-solving and effective collaboration skills. In addition, collaborative activities are a basic dimension of PBL and they do support students' capacity to learn meaningfully in order to become the future citizens in the knowledge-based society of the twenty-first century [10, 12]. Many researchers argue that the integration of technology into a PBL learning environment can lead to more meaningful learning. The implementation of the PBL in an online environment includes the students' active participation and work in small groups so that they solve a series of sub-problems as part of tackling a main problem [20, 21].

Bearing all these in mind, the current study makes use of the educational framework of PBL and the Jigsaw II strategy in an educational scenario in order to enhance collaboration and language learning skills in a Computer Supported Collaborative Learning (CSCL) environment. The proposed educational scenario is embedded in a content management system (Moodle). In this environment students interact and collaborate in groups and as a result, they build common collaborative learning experiences and improve their language learning skills. More specifically, the aim of this research is to evaluate the usefulness of an educational scenario, designed along the principles of a PBL model and Jigsaw II collaborative strategy in a CSCL environment (Moodle) with the aim of fostering collaboration and learning skills in language among high school students.

2 PBL and Language Teaching

According to the curriculum for language teaching - in the first grade of high school - one important goal of teaching the subject of "language" is that students should obtain such a level of language proficiency that will enable them to respond to the social needs of today, to be prepared to face critically and efficiently the rapidly and ever-changing conditions of a globalized world and to become literate, democratic and critically-thinking citizens.

Taking all the above into account, it is obvious that neither the traditional teacher-centered teaching model nor the one-dimensional content approach involving the extensive decoding of texts can meet the demanding needs of 21st century language education. In contrast with traditional teaching methods, active learning holds the promise of being the basic factor behind improved educational results. For this reason, problem based learning (PBL) as a teaching method that activates learners is being applied at an increasing rate in education. Since its initial application in medical school programs in health sciences at the McCaster University in Canada from the late 1960s onwards, it has recently expanded to all sorts of educational domains and levels in order to address diverse educational challenges. Recently, PBL has also gained ground in secondary education as it helps learners to develop a great variety of skills [14, 23, 25].

In the same way, PBL could also prove beneficial in the domain of humanities. More specifically, it seems it could prove to be a more efficient theoretical framework and it could provide an alternative instruction method in secondary education language teaching too, since it can prepare students for real-life problems through social interaction based on real-life conditions. Consequently, it could help students understand the variety of language use in real situations by familiarizing them with different language styles appropriate for different communication channels found in real life, and not by forcing them to memorize theoretical knowledge “about” language. In addition, by presenting them with “ill-structured” problems with no definite answers students can prepare themselves for the complexity of real-world and develop their critical thinking and argumentation skills [17].

Finally, the whole process of solving the “ill-structured problem” by taking decisions, searching and evaluating relevant sources, exchanging ideas and presenting results, enhances their language skills in terms of grammar, vocabulary and language use in different social environments and in real-world contexts. In short, they construct an understanding of language “in use” and “as it is used”. For all the above reasons, PBL can prove to be an efficient instruction method in language teaching and particularly in helping high school students improve their collaboration and learning skills, as it will be argued in this study. In what follows we claim that PBL is one of the most suitable methods so for enhancing collaborative and language learning skills in the Moodle environment.

3 Moodle and PBL: A Compatible Collaboration

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open-source online Learning Management System (LMS) which is widely used for effective online collaborative learning in higher education and other contexts. Moodle mainly supports and is based upon, although not exclusively, the principles of social constructionist pedagogy according to which the role of social groups is very important for the construction of knowledge and learning in general [6]. More specifically, according to social constructionist pedagogy, students’ learning outcomes increase as a result of interaction with their peers [18].

Moodle affordances can be multiplied if combined with problem-based learning (PBL) in which students’ learning derives, among other things, from the development of problem - solving and effective collaboration skills [10, 24]. Basically, PBL is a method in which students work in groups while the tutor’s role is the role of a facilitator of the learning procedure through scaffolding and monitoring [24].

On the other hand, PBL fosters group collaboration so that students can reach a solution to an “ill-structured” problem and by doing so, it is a method that improves students’ thinking skills as well as their social and communication skills through active collaborative learning [19].

Taking into consideration that group collaboration is a major element in the success of PBL, it is obvious that PBL can be applied successfully to Moodle and other Learning Management Systems of a collaborative nature in many disciplines and in particular, in language learning so as to improve the students’ language learning skills through collaboration.

4 Collaboration and Language Learning Skills

Collaboration skills are considered to be particularly important among 21st century skills. Students have to complete various tasks within groups in order to prove that they can collaborate successfully. In particular, collaborative skills are associated with the development of the qualities below [8, 15]: (a) Team Spirit: This refers to group activities and to the procedure by which individuals can work together. (b) Collaborative Culture: This refers to the common targets, respect and mutual concessions each team member has to make, as well as to collaboration and learning. (c) Trusting Partnerships: This refers to skills connected with trust, respect and team action. (d) Collegial Consonance: This refers to team relationships which develop when students collaborate, discuss and share ideas, knowledge and strategies.

At the same time, learning skills [15] are being increasingly recognized as preparing students for a more and more complex life and work environments in the 21st century. In this study, there is a focus on creativity, critical thinking and problem-solving as parts of the above-mentioned learning skills and as important elements for the preparation of students in real-life language situations.

More specifically, creativity consists of [15]: (a) Creative thinking: this includes the following: (i) The use of a wide range of idea-creation techniques (such as brainstorming) (ii) The creation of new and worthwhile ideas (both incremental and radical concepts) (iii) The elaboration, refinement, analysis and evaluation of one's own ideas in order to improve and maximize creative efforts. (b) Creative work with others; this refers to the following: (i) The development, implementation and communication of new ideas to others effectively (ii) Being open and responsive to new and diverse perspectives; incorporate group input and feedback into the work (iii) The demonstration of originality and inventiveness in work and understanding of the real-world limits to adopting new ideas.

Also, critical thinking and problem-solving consists of [15]: (a) Effective reasoning which involves the use of various types of reasoning (inductive, deductive, etc.) as the situation demands. (b) The ability to make Judgments and Decisions; this refers to: (i) the effective analysis and evaluation of evidence, arguments, claims and beliefs (ii) the synthesis and connections between information and arguments (iii) the interpretation of information and the drawing of conclusions based on the best analysis (iv) Critical reflection on learning experiences and processes. (v) Critical thinking on current national and international social and cultural matters. (vi) Critical reflection on current global and local problems (vii) Critical reflection on issues related to multiculturalism and tolerance towards diversity. (c) Problem- solving; this refers to: (i) Solving different kinds of non-familiar problems in both conventional and innovative ways. (ii) Identifying and asking significant questions that clarify various points of view and lead to better solutions (points v, vi and vii are based on the Greek curriculum for the first grade of high school in language learning).

Since we have noticed that Moodle and PBL can be combined effectively in order to develop collaboration we have designed the present research in the context of the teaching of Modern Greek Language as described in the next unit.

5 Method

The aim of this research is the evaluation of the design and implementation of an educational scenario based on the principles of a PBL model combined with the Jigsaw II collaborative strategy in a Computer Supported Collaborative Learning (CSCL) environment and specifically on Moodle, in order to enhance collaborative and language learning skills. In particular, the research questions (RQ) in which the present study is focused on are the following:

RQ1: To what extent does a CSCL environment designed on the basis of a PBL educational scenario promote collaboration skills?

RQ2: To what extent does a CSCL environment designed on the basis of a PBL educational scenario improve the language learning skills of students in Language?

The participants in this study were 20 students in a secondary school in Athens taking part in a program on Human Rights. The program was conducted as a unit in the subject of Language.

Experimental Procedure. The research was conducted using one group in one High School class. The subjects of the study (20 fifteen-year old high school students) were engaged in the training process through the PBL scenario in order to enhance their collaboration as well as their learning skills in Modern Greek. In particular, the PBL scenario was implemented through a series of 6 Sessions (one session per week). Each session comprised one on-line and one face-to-face encounters in order to solve the 'ill-structured" problem set by the design of the educational scenario.

The PBL Scenario. The collaboration scenario implemented follows the principles of the "Maastricht 7-step" models: the "7-jump approach" by Maurer, and Neuhold [13] and the "Maastricht 7-step" by Savin-Baden [20, 21] both based on the "Maastricht 7-step" and Jigsaw II strategy. The proposed PBL scenario is embedded in a CSCL environment, and in particular in a content management system (Moodle). The structure of this PBL scenario (Fig. 1) involves the students in a number of activities while they adopt different roles in order to enhance the learning outcomes [8].

Step 1: Stating the ill-structured problem - Clarification terms and concepts - Initial Groups (Session 1)

The PBL scenario commences with an ill-structured problem, which serves as a road-map for the learning procedure. More specifically, students are invited to provide a solution to the following problem: "Little Bob and the defense of human rights". The scenario of the ill-structured problem is presented in the form of a dramatized story shown on video. The story goes as follows: *"Bob, the little protagonist, is a victim of bulling. So, he creates a shuttle and sends it all over the world, to people of every race, religion, age and gender to inform them about human rights' violations. Bob's message finds supporters who coordinate and unite their voice as a means of support to him. Grown-ups and children united confront human rights enemies and defend the value of human rights and the need for everyone to contribute to their protection".*

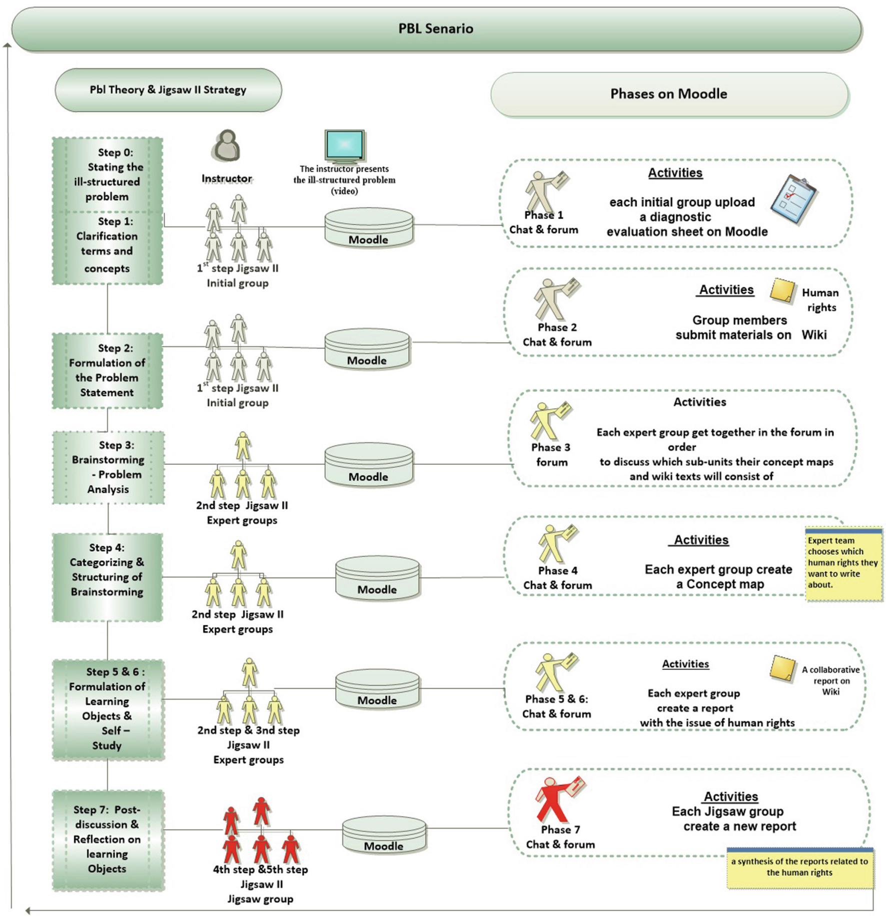

Fig. 1. PBL scenario: theory, jigsaw strategy and moodle phases.

After watching the video, students are asked to explain the problem of breaches of human rights nowadays and seek their own explanations and solutions.

Task type: Students participate in discussion activities (face-to-face and online mode) in order to clarify the concepts of the ill-structured problem. **Group type:** four five-member teams are formed (initial groups – 1st step [Jigsaw II]) and the roles of the members (student chair, secretary, group member) within each group are determined. **Activities:** Students go through the "Study Material" in the CSCL environment (documents concerning the history of human rights). Afterwards, each team has to upload a diagnostic evaluation sheet on CSCL environment in order to check the students' prior Knowledge (activity 1). **Group engagement:** Communication between the members of each group (initial groups) is done through the chat and the forum. They discuss the violations of Human Rights that they have heard of or have witnessed themselves. The student chair coordinates the discussion on the chat and forum.

Step 2: Formulation of the Problem Statement – Initial groups (Session 2)
Task type: With this task, students define the terms and concepts of the problem under consideration and discuss the possible reasons why the ill - structured problem exists. **Group type:** four five-member groups are formed (initial groups – 1st step [Jigsaw II]) and the roles of the members (student chair, secretary, group member) within each group are determined. **Activities:** Group members submit the materials about the different kinds of human rights and their violations to each group's collaborative Wiki in the CSCL environment (activity 2). **Group engagement:** Each group (initial groups – 1st step [Jigsaw II]) gets together in the forum and on chat in order to discuss the issue of human rights and the causes of their violations, to contribute relevant digital material (activity 3) and then to answer the questions. The student chair coordinates the discussion on the forum and chat.

Step 3: Brainstorm- Problem Analysis – Expert groups (Session 3)
Task type: The students discuss which human right they would like to study. They use the brainstorming technique to activate their prior knowledge. **Group type:** At this stage, the group composition changes. The students who choose the same humans rights theme work together on the relevant sub-units (value, causes of violation, results, solutions) they are going to work on (5 expert groups of 4 members each – 2nd step [Jigsaw II]). More specifically, they select a specific human right per expert group. **Activities:** Each member of each expert group expresses their opinion about what sub-unit they will choose in order to create a text about a human right. The secretary of each expert group takes notes and records each member's opinion. Each expert group chooses which human rights they want to write about and the teacher intervenes where necessary. Finally, they discuss on the forum and they decide about the sub-units that will be included in the concept maps and in the text, they are going to create in the following sessions (session 4 and session 5). **Group engagement:** Each group (expert groups – 1st step [Jigsaw II]) gets together in the forum in order to discuss which sub-units their concept maps and wiki texts will focus of.

Step 4: Categorizing and Structuring of Brainstorming – Expert groups (Session 4)
Task type: Each group member selects a certain sub-unit of the human rights which corresponds to the human right each expert group has selected. Then the expert groups discuss in the forum. They negotiate the structure of a collaborative report integrating a sub-unit that each member will study. **Group type:** The students are divided into 5 expert groups, according to the human right each group has selected to work upon (expert group 1, 2, 3, 4 and 5 - 2nd step [Jigsaw II]). **Activities:** Group members decide on the allocation of the tasks which each member of each expert group will undertake to complete. The classification and organization of their ideas is done with the aid of concept maps (activity 4). **Group engagement:** Each team (expert groups – 2nd step [Jigsaw II]) carry out their discussions in the forum.

Step 5 & 6 Step: Formulation of Learning Objects & Self – Study - Jigsaw group (Session 5)
Task type: Each student deepens his/her knowledge about human rights (self-study). As students have by now become 'experts' on particular human rights (women's rights, the right to a good standard of living and the fight against poverty, the right to equality and

the fight against racism, the right to safety and peace, the right to life in relation to the death penalty, etc.) (2nd step [Jigsaw II]) they discuss in the chat in order to deal with any queries they may have and they ask for clarifications. They create a report (activity 5) on the issue of human rights they have selected as well as the tasks that each member of the group has undertaken. Following this, they return to their initial groups (now transformed into 'jigsaw groups') in order to share their knowledge in their forum with the rest of the members of their initial group. **Group type:** With this knowledge transfer, the initial groups are now transformed into 'jigsaw groups' (3rd step [Jigsaw II]): expert group1: "women's rights", expert group 2: "the right to a good standard of living and the fight against poverty", expert group 3: "the right to equality and the fight against racism", expert group 4: "the right to safety and peace, and the right to life in relation to the death penalty". Jigsaw groups: 1,2,3,4 (4 groups comprising 5 members each). **Activities:** Initially group members study individually (self-study) and afterwards one of them submits the report created in each team's wiki on Moodle (activity 6). **Group engagement:** Students become experts (2nd step [Jigsaw II) and they discuss in the chat and ask for clarifications in order to deal with any queries they may have.

Step 7: Post-discussion & Reflection on learning Objects (Session 6)
Task type: Members of each Jigsaw group study the report based on human rights, discuss about its content and form in the forum and they collaborate in the creation of a new one arising out of a synthesis of the reports related to the human rights (activity 7). Finally, they assess and evaluate the whole process which has led to their newly-acquired knowledge (4th and 5th step [Jigsaw II]). **Group type:** Jigsaw groups (4 groups comprising 5 members each). **Activities:** Members of each group study the reports, collaborate and create a new one which the secretary uploads on Moodle. **Group engagement:** Group members discuss (in the forum). They fill in rubrics of self- and peer-evaluation individually in which they acknowledge and evaluate the contribution of the group in the final solution.

The results of the implementation of this educational scenario will be discussed in the next unit.

6 Results and Discussion

In this study, we used a mixed method of data analysis, where we combined quantitative and qualitative data [3, 5]. This combination allows the validation of research results. Specifically, we analysed the context of the chat, forum and wiki log files, in order to record the behaviour of the students as they interacted in various ways in the CSCL environment according to the PBL educational scenario. We took into account a number of qualitative criteria related to collaboration and language learning skills. There was also a quantitative analysis of the various indices. For this we used the method of pairwise comparisons with Bonferroni adjustment (repeated measures). In particular, we measured the number of times students interacted in a technology enhanced learning environment (Moodle) and they managed to (a) complete their group activities while working together (Team Spirit/TeSp); (b) develop respect, set common goals and help each other (Collaborative Culture/CoCu); (c) trust different views among group members (Trusting Partnership/TrPa d) become more responsible as they discuss and share ideas within their groups (Collegial Consonance/CoCo).

In relation to language learning skills, we measured the number of times students interacted on Moodle and managed to develop creativity as they (a) created new ideas and also elaborated, analyzed and evaluated them (Creative thinking/CT) and (b) developed, implemented and communicated their ideas to others, were open to new perspectives and demonstrated inventiveness (Creative collaboration/CC). To this end we measured the times students interacted and managed to develop critical thinking and problem-solving skills and more specifically to (a) use various types of reasoning (effective reasoning/ER) (b) analyse, evaluate arguments, synthesize and interpret information, reflect critically on a variety of subjects (ability to make judgments and decisions/DJ) and (c) solve different types of problems by posing proper questions that lead to better solutions (Problem – solving/PS).

We calculated the successive difference of the average values of the frequency with which each index appeared between sessions (session 1–2, session 2–3, session 3–4, session 4–5, session 5–6). We did this for all 6 phases for all the criteria. For this study, all subjects were rated by four (4) coders (Tutor, Self. Peer, ExVal). The researcher is interested in assessing the degree to which coder ratings were consistent with one another such that higher ratings by one coder corresponded with higher ratings from another coder. So we calculated (Table 1) the intraclass correlation (ICC) which is a useful estimate of interrater reliability (IRR). An IRR estimate of 0.74 (ICC(2, 4) = 0.74), which is considered good [1] indicates that 74% of the observed variance is due to true score variance or similarity in ratings between coders and 26% is due to error variance or differences in ratings between coders.

Table 1. Intraclass correlation coefficient

Measures	Intraclass correlation[b]	95% Confidence interval		F Test with true value 0			
		Lower Bound	Upper Bound	Value	df1	Df2	Sig
Single	,421[a]	,197	,664	3,910	19	57	,000
Average	,744[c]	,495	,888	3,910	19	57	,000

Two-way mixed effects model where people effects are random and measures effects are fixed. a. The estimator is the same, whether the interaction effect is present or not. b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance. c. This estimate is computed assuming the interaction effect is absent, because it is not possible to estimate a value otherwise.

In analysing the results, we noticed that most of the indices related to the students' collaboration skills (RQ1) are statistically significant. Table 2 shows that especially during sessions 2–3 and 4–5 the number of exchanges among the students is quite high. This is possibly due to the structure of the educational scenario on the one hand and on the other to the type of activities incorporated in Moodle.

Table 2. Results based on the method of pairwise comparisons related to collaboration skills

Collaboration skills		Sessions - Mean differences				
		Session 1–2	Session 2–3	Session 3–4	Session 4–5	Session 5–6
Criteria/indices	Team Spirit (TeSp)	−0.600	4.400*	−4.400	7.000*	1.600
	Collaborative Culture (CoCu)	−3.600*	3.800*	−0.500	4.800*	2.100*
	Trusting Partnerships (TrPa)	−0.667	6.000*	−2,333	1.667[a]	−1.667
	Collegial Consonance (CoCo)	−0.800	4,800*	2.800*	−0.400	−2.600

* The mean difference is significant at the .05 level.

For example, the index Trusting Partnership (TrPa) during sessions 2–3 appears to be statistically significant. This means that the educational scenario provided the opportunity for students to participate actively in the various collaborative tasks and to interact with each other as they engaged in the learning process. In particular, students become more active and trust different views among their group members. In sessions 2–3, according to the jigsaw II strategy (1st step), they participate in the expert groups in which they have to decide what unit and sub-unit they will work on. Additionally, according to the PBL scenario (steps 2–3), they are trying to analyze the ill-structured problem by using the brain-storming technique. Also, the index Team Spirit (TS) in sessions 4–5 appears to be statistically significant too. This is possibly due to the fact that students discuss about the structure of a collaborative report in their expert groups, according to the jigsaw II strategy (2nd step), integrating a sub-unit that each member have studied. Afterwards, according to the PBL scenario (steps 4–5, 6) they complete many activities as members of the jigsaw groups (3rd step of Jigsaw II). The above findings are also confirmed through a qualitative analysis of the chat and forum messages exchanged by the students during the sessions. Examples of such exchanges related to Collaborative culture criterion are given below (session 3, expert group 4):

Member 1. So, I propose that we divide our text into 5 paragraphs - one for each member of our group. Member 2: I think your idea is excellent! Member 3: But what would you say if we mentioned the opposite theme in another paragraph? We will have a better result! Don't you agree? Member 4: I totally agree!

The interpretation of the students' language learning skills (RQ2) was done through analyzing the content of the chat, the forum and the wiki log files. During the sessions students participated in a set of activities in order to produce concept maps, paragraphs and reports through collaboration. Table 3 shows that many indices related to the students' Language Learning skills (RQ2) are statistically significant.

Especially in sessions 2–3 and in sessions 5–6 we observe that students developed high-level creative thinking and problem-solving skills (indices CT/PS). In addition, they improved effective reasoning and judgment-making and decision-taking skills (indices ER/DJ). In these sessions, students improved the above-mentioned skills

Table 3. Results based on the method of pairwise comparisons, related to Language learning skills

Language learning skills		Mean differences				
		Sessions 1–2	Sessions 2–3	Sessions 3–4	Sessions 4–5	Sessions 5–6
Criteria/indices	Creative Thinking (CT)	−0.500	2.500*	0.000	2.000*	3.500*
	Creative Collaboration(CC)	0.333	1.667*	0.667	1.667[a]	3.000*
	Effective Reasoning (ER)	−0.333	−0.667	0.333	1.000	2.667*
	Making judgements and decisions (DJ)	−1.714	0.429	2.571*	1.000	3.714*
	Problem Solving(PS)	1.000	4.000*	−5.000	1.000	7.000*

* The mean difference is significant at the .05 level.

possibly due to the fact that they participated in expert and jigsaw groups (2nd and 3rd steps of Jigsaw II) and also because they were asked to deliver their collaborative texts and reports (steps 5, 6, 7 of the PBL scenario). As far as sessions 1–2 are concerned, we observe that the indices are not statistically significant. This fact is possibly due to the fact that those were the early stages of the educational scenario and so there had not been any significant change in students' behavior yet. The qualitative analysis of the chat and forum messages and wiki texts confirm the above. Examples related to the critical thinking criterion are given below (session 5, expert group 2):

Member 1: Human rights are violated in different parts of the world, especially in third world countries. Member 2: It is true, but we should stress that in western countries too there are many violations especially as far as the right to equality is concerned. Member 3: I agree with you. We should get over the myth that only third world societies face this problem! Member 4: We should also focus on the so-called "developed" societies…

Generally speaking, the proposed educational scenario helped students to improve their collaboration and language-learning skills as they executed a number of related activities and interacted within a variety of groups.

7 Conclusions and Suggestions for Further Research

In this study, we tried to investigate whether the design and implementation of an educational scenario following the principles of a PBL model and Jigsaw II collaborative strategy on Moodle would improve collaboration and language learning skills among high school students. We observed an increased tendency on the part of the students to collaborate and to engage in ever more active participation in the learning activities their teams were involved in. Another thing the results show is the development of Collaborative Culture skills among the students as they involve themselves in the various activities. This is probably the result of the increased familiarity the students develop with each other, as they work together in the various teams through Jigsaw II. In addition, we can see that high school students come to develop high levels of mutual trust with their team members. As a result of the discussions they have with the other members of their team, the high school students come to develop greater trust in their ideas and they become more accepting and more respectful of the way the others work. Another thing we notice is the development of Collegial Consonance skills among the high school students. As they progressed through the various groupings (initial, expert and jigsaw teams) we notice students collectively taking decisions about the way they work and the responsibilities each other has.

Quite apart from all the above, our analysis shows that the students' involvement in the various collaborative activities within the CSCL environment also results in their developing creative thinking skills as well as an ability to make judgments and reach decisions. The way PBL is embedded within the CSCL context practically ensures that students have to collaborate creatively in order to access information and to inform others, to try to influence or motivate the other team members so as to solve problems, and to reach decisions about how they are to carry out the various tasks they need to complete during the various stages of PBL.

This scenario was a challenging experiment, since high school students in the Greek secondary education system are more familiar with traditional language learning approaches. Perhaps as a result of this, as data analysis indicates, students showed an increasing interest in collaborative activities on a technology enhanced learning environment (Moodle) as well as an improvement in their creative, critical thinking and problem-solving skills in relation to language-subject material. In this study, the results demonstrate that students do not use technology simply to interact with their peers but also to organize their thoughts, which results in improved learning skills. For future research, it would be interesting to apply this teaching method in order to improve not only content-oriented language learning skills of students but also their command of vocabulary, syntax and the grammar structure of the language. It could be also applied to other subjects in the field of Humanities. Last but not least, involving a larger number of students in such studies could give a better idea about the successful use of this teaching method in combination with various collaborative strategies. This last point is particularly important and is one on which future research should certainly focus on.

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Problem Solving and Knowledge Transfer

Lesson Learned Management Model for Solving Incidents in a Company

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Abstract. This article is focused on explaining the results of a research project that outlined a management model of lessons learned for solving incidents in a company, which started with the identification of the problem, pointed out the disadvantages currently faced by organizations to give solution to the incidences. It was based on a conceptual framework that gives a preliminary description of some of the most commonly used incident management tools in organizations and approaches the application of knowledge management, lessons learned and incident resolution participants.

Lessons learned are a very important factor for companies in managing knowledge and analyzing what has been generated, over time these become an asset that makes companies more productive leading to best practices and quality improvement.

In the development of this model, we investigated the models of existing lessons learned, resulting in a problem-oriented lessons learned model based on the best practices of ISO 9001 and ITIL [1–3].

Keywords: Lessons learned · Knowledge management · Issues · Best practices

1 Introduction

Organizations need to be more productive and take advantage of their employees' work efficiently, if they have knowledge bases and lessons learned, there would be a continuous growth of knowledge in the company, which would allow a better use and greater quality in the response to incidents occurring within the company's internal areas.

Likewise, the amount of information that companies manage indicates that the knowledge and the solutions generated must be carried in an information system for the management and timely management by the employees of the companies, managing to classify the problems and providing the solution more effective according to the knowledge accumulated by the people who solved the problem in the past, is why it was considered to generate a management model of lessons learned in the day to day of the company.

It was necessary to generate internal knowledge of the management and types of solutions that are given to the incidents, in that sense it became necessary to keep a

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record of the solutions presented to the incidents, classifying them to determine the solution of the incident, and the most important thing to contribute A knowledge of the company's personnel when the same incident is resolved or a similar incident must be resolved, helping to guide the solution, this gives the employee and the company benefits in terms of improving internal processes.

2 Problematic

In companies, due to the constant turnover of personnel or simply due to promotions and changes in internal processes, the loss of information and knowledge acquired by employees over time results, due to lack of management of the lessons learned.

In addition to the time lost in the solution of the incidents should include the time spent by the employee to generate such knowledge during the development of their activities, when entering to analyze this situation it is seen that each employee has a learning curve within the company on the issues that it begins to manage, it is here where the problem of the loss of knowledge is evidenced, since this impacts the times of response of the incidents and consequently the indicators of management of the area.

Which led to this research project to raise the following research question: How to generate a model of lessons learned that allow the solution of incidents in an organization? [4].

3 Applied Methodology to Develop the Model

Since the proposed system was intended to implement a model of lessons learned, it was based on two key points of Thomas Davenport's methodology [5], which are:

– Use of knowledge
– Retention of knowledge

The project methodology was also supported by Scrum [6], performing the project tasks in a collaborative way in order to obtain results sooner with the idea of partial deliveries and not feedback from the results with this began to describe the steps which are followed in the methodology applied in the project.

The first step was to compile the basic characteristics that handle the incidents in order to determine the points in which the model should be focused and to give value to the lessons learned [7], in addition to applying a survey to assess employee relevance.

The model of existing lessons were further analyzed to define a new model based on the critical points, problems encountered, advantages, disadvantages, risks, strengths and key steps which could base the new model, it took the business environment having a phase, after this stage adjustments were made to both the model and the typifications use and search of the lessons learned, after documenting these phases a new iteration of the step described above was generated [8], bringing the model back to the business environment, with the corrections obtaining a feedback again, this process was applied until a model according to the handling of the lessons learned for the solution of incidents within a company.

4 Information Gathering

4.1 Survey Approach

In order to know the perception of the employees of the organizations about the importance of the lessons learned and their value within the organizations in terms of time and quality of the solutions, a series of surveys were applied which were directed to the personnel of the financial institution that was where the model of lessons learned was set up, and external active workers to test the management of lessons learned within the organizations where they work, these surveys were conducted during the month of September 2016 and the type of questionnaire that was carried out was of an investigative type, a list of 18 multiple-choice questions with a single answer was carried out.

4.2 Purpose of the Survey

The questions of this survey, it try to determine:

- The organizational culture of the financial institution to know the best way to design the model, so that employees do not generate rejection and motivate them.
- Validate relevant data with which the model of lessons learned should be counted.

4.3 Methodological Design of the Survey

The orientation of the survey questions was made taking into account the current context of the company. It was sought to determine if analysts perform the documentation of their jobs and in the opposite direction verify the reason why they do not, in order to establish the relevant data that must be had to generate the model of lessons learned, the survey was designed according to the following criteria:

- Questions are multiple-choice with only one answer.
- Questions are grouped by the common objective for which information is required.
- The survey was published in a Google form.
- The population of the survey had knowledge related to the systems engineering career and the employees of the financial institution in the IT area.

The survey handled the following independent variables:

- Time spent by analysts to document.
- Motivation of the employee to document.

The survey handled the following dependent variables:

- Reprocessing of tasks.
- Established processes.
- Knowledge of processes.
- Autonomy and self-management of analysts in their tasks.

The variables defined for the survey are listed in Table 1, indicating its dimension, which is how the variable is to be measured and the indicator that indicates the period of the variable.

Table 1. Variables of the survey. Source: Authors.

Variable	Dimension	Indicator
Motivation of the employee to document.	Disposition	Nominal
Time spent by analysts to document.	Time	Frequency
Reprocessing of tasks	Time	Periodicity
Processes established	Fulfillment	Nominal
Process knowledge	Fulfillment	Nominal
Autonomy and self-management of analysts in their tasks	Disposition	Nominal

4.4 Reliability Factors

In order to validate the reliability of the survey, we have the factors described in Table 2 which are evaluated according to compliance, and are judged arbitrarily by the authors.

Table 2. Factors of reliability of the survey. Source: Authors.

Factor	Fulfillment	Medision	Valor
Length of test	20 questions	High	0.85
Speed	Unlimited	High	1
Homogeneity of the group	Engineers, financial institution, analysts	High	1
Difficulty of items	Knowledge of terms, clarity of questions	Media	0.5

4.5 Application and Consolidation of Survey Results

The surveys were carried out on a group of 39 employees from a population of 50 employees of a financial sector company in the technology area, which indicated that the confidence level of the sample was 85% with a probability of 6% of error.

4.6 Analysis of Survey Results

As a result of the questions asked to the staff of the technology area of the financial institution, it was concluded that:

- There should be several changes in the organizational culture in order to improve the spaces for feedback and also to generate spaces for documentation accompanied or guided by senior staff.

- There are key factors for the construction of the format that is done in the model already having determined that is the most important and what is the most valuable when it comes to completing and consulting a lesson learned.
- Several key points to be taken into account in the creation of the lessons learned management model are identified, such as employee motivation aspects and the presentation of results to managerial levels so as to see the advantages and benefits provided by the model.
- It highlights the problem of loss of knowledge at the time of change of position or retirement of an employee, which causes delay and difficulties in the process of resolution of incidents to the current staff of the company, this is translated into reprocessing and loss of time.

5 Model Lesson Learned Management for Solving Incidents in a Company

The management model of lessons learned was designed taking into account several factors that were reviewed and analyzed in this research work, such as:

- Current process of incident management of the company.
- Surveys with the objective of collecting information necessary for the model.
- Comparative analysis of some existing models of lessons learned.

It was based on organizational culture, which is very important because it depends on this aspect that the model is welcomed and useful for the company.

The model proposed in Fig. 1 is subject to a process and/or phases that indicate the key elements in the management of lessons learned:

- Documentation of the lesson learned.
- Cataloging of the lesson learned.
- Dissemination of the lesson learned to stakeholders.
- Application of the lesson learned.
- Continuity documentation of the lesson learned.
- Learning at the workplace.

According to the above, a management model of lessons learned in a spiral was proposed, in which continuous documentation becomes intrinsic, and continuous learning in the workplace is value added and fundamental pillar, to make a continuous improvement in the basis of lessons learned proposed a continuous stage of control and follow-up, which can be rethought as organizational culture improves.

The phases of the model are described below:

- *On-the-job learning*

With the continuous use of the basis of lessons learned the employee is acquiring a structure of learning and methodology in resolving incidents that are presented to him in his work place, contributing an added value to the employee and the company this is translated in a classification of the incidents achieving agreements of real service levels

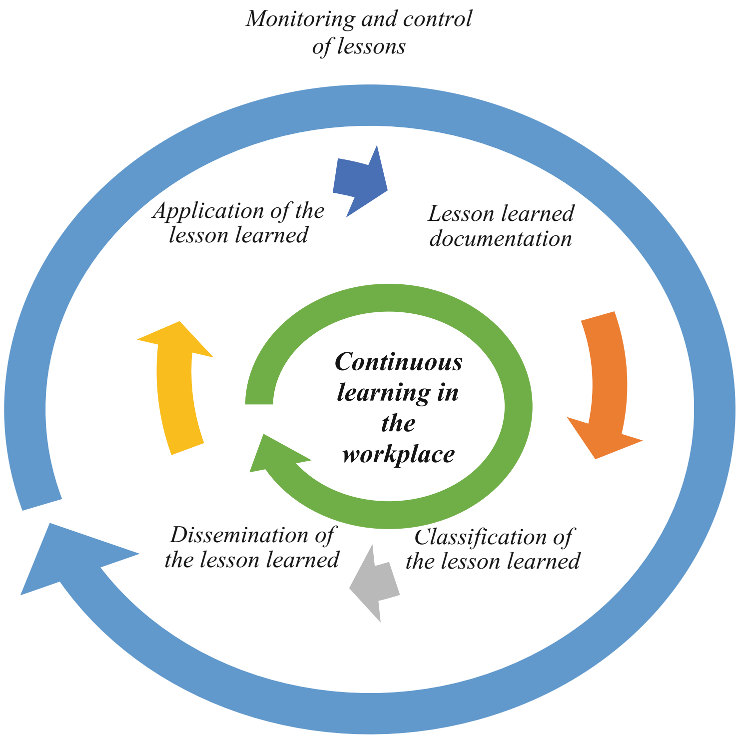

Fig. 1. Management model of lessons learned Source: Authors

based on the solutions made and a better distribution of incidents to the employees according to the time described in the lesson learned, contributing to the area of technological management a *better perspective* of the resolution of incidents.

- *Lesson learned documentation*

In this step when resolving an incident for the first time, the lesson learned should be documented according to the format proposed for this, the analyst must be counted on, since this step is of vital importance in the model.

- *Classification of the lesson learned*

It is important for the model to carry out a verification of the lesson learned and to verify that it is accessible and clear to the interested parties, which is why it is of vital importance that it be cataloged by a group of analysts and complement the keywords by common language in the format descriptions.

- *Dissemination of the lesson learned to stakeholders*

In order for the lessons learned to contribute to the solution of incidents, a correct dissemination of the lessons learned must be made, they must be left to the reach of the whole organization in order that they be the first step that the analyst executes in the process of documentation or resolution of an incident, it is previously required a training on how to fill out the format and where to find it.

- *Application of the lesson learned*

To be able to apply the lesson learned, the employee must first perform a task of analysis of the problem and then perform a search in the base of management of lessons learned, for this the employee must determine the following factors:

- Project or areas in which the incidence is presented.
- Keywords.

With these factors you can proceed to search the project folder and through the field "keywords" perform a search for the lessons learned that match, as the second step is searched for the field "description of the incidence" for determine if it can be used to solve the problem.

If one or several learned lessons are found that match the words, the "Solution description" field is reviewed, which makes a description of the solution if the lesson is identified for the incident. The "prerequisites to apply the solution" this in order to verify that you have the necessary elements before you start implementing the solution.

If all the factors described above are fulfilled, proceed to implement the solution contained in the lesson learned described in the field "Description of the solution" in which a summary of the solution is given and a step by step of the solution process.

- *Continued documentation of the lesson learned*

In order to update the basis of lessons learned from a process of updating them, this process is done at the time of the solution of an incident based on a lesson learned by the employee, if:

- The described process of the solution has changed
  If the application of the lesson learned verifies that there are missing or missing steps in the "solution description" field, the employee must update this field with the new information and the fields "Update date", "Version".
- Prerequisites changed.
  If the prerequisites described in the "Prerequisites for Applying the Solution" field were created or changed, the employee must update this field with the new information and the "Update Date", "Version" fields.
- Improvements were found in the solution.
  If the problem solving is a better way to solve the problem or there is optimization in the steps described in the field "solution description" the employee must update this field with the new information and the fields "Update date", "Version".

5.1 Lesson Learned Format

The format of the lesson learned was designed based on the information gathered in this project, in order to contain the necessary information and support when documenting a lesson learned, being also easy to read and updated or improved the lessons learned should be stored by projects or areas in order to make it easier to visualize them and to mitigate the risk of generating two lessons learned from the same incidence, the fields to be carried out by the format proposed in the model of lessons learned is found in Table 3.

Table 3. Fields formatted lessons learned. Source: Authors.

Field	Description
Date	Date on which the lesson learned was documented
Version	Indicates the version number of the lesson learned in order to determine how many updates you have had
Date update	Date last updated lesson learned
Author	Indicates the name of the employee documenting the lesson learned
Keywords	They reference the keywords of the lesson learned in order to be able to search more concretely
Description of the problem, problem or opportunity for improvement	A detailed description of the problem can be solved with this lesson learned
Prerequisites for applying the solution	This field indicates if there are prerequisites that the employee must take into account in order to carry out the solution of the incident e.g. (Applications, passwords, dates, top-level approval)
Description of the solution	A step-by-step description of the solution to the problem set out in the description of the problem
Type used in the solution	This field indicates the time spent by the employee in the process of performing the solution, with this field you can establish service level agreements
Lesson learned and/or recommendations	In this field a summary of what was learned about the problem is made and why the solution is adequate, is an analysis of the process of solution of the incidence

6 Evaluation of the Lessons Learned Management Model

For the time that implies to carry out the evaluation of the model, a phase after the ones presented here was proposed, the model of management of lessons learned is evaluated by means of the following steps:

Step 1: Contextualize the team of analysts on the concept of a lesson learned and explain the proposed model.

Step 2: Start with two computers an implementation of the model.
Step 3: Receive feedback from the model on the part of the two teams in order to identify accuracies, shortcomings, presented drawbacks, opportunities to improve formats, opportunities to improve the model.
Step 4: Apply improvements.
Step 5: Change the test computers and start implementing the model on those computers.
Step 6: Receive feedback from the model on the part of the two teams in order to identify accuracies, shortcomings, presented drawbacks, opportunities to improve formats, opportunities to improve the model.
Step 7: Application of improvements, familiarization and explanation of the lesson format learned in order to make it easy for them to be diligent and read, to all analysts.
Step 8: Follow up on the knowledge base of lessons learned.
Step 9: Feedback to analysts.

7 Conclusions

In carrying out the research work of the model of lessons learned the following conclusions were obtained:

- The lessons learned model proposes a change of organizational culture, showing the employee the importance of documenting their work and the value that this generates for the same and for the company.
- The molding makes a classification of the incidents, determining in which project are presented more and their origin and/or cause, this allows to make a process of continuous improvement at the level of the area allowing to improve its processes and helping in the visualization of corrective measures.
- The model proposes a continuous improvement with the constant uses and updating of the lessons learned, achieving a robust and updated basis.
- With the base of lessons learned allows to know the actual times of the solution of incidences since this is documented in the format of the lesson learned and as this solution is used and updated a real time of solution is obtained that can be used To establish service agreements.
- At the time of change of position or retirement of an employee, the company mitigates the loss of knowledge with the basis of lessons learned by providing tools to the new employee in the resolution of incidents.
- An analysis of the management that is given to the incidents generated within the company and how the model contributes to its resolution and continuous improvement.
- With the incident base you can see the most common incidents in order to take them into account in the execution of future projects.
- The model makes management visible to projects with the highest number of incidents, allowing them to make decisions in order to generate opportunities for improvement.

8 Recommendations

The realization of this model allows to propose the following recommendations in order to give complementary ideas to the research developed.

- It can be complemented by an organizational culture work and proposals to improve them.
- Make a larger sample to increase confidence and counter survey results with different companies and technology areas.
- The described fundamentals of the model can be used as bases in the generation of a knowledge management model.

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Mapping Curricular Ecologies

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Abstract. The impact of socio-economic changes and technological advancements is prompting many educational institutions to re-think the processes of planning, designing and delivering courses in Higher Education. The effect is a re-emergence of the importance of curriculum design. The aim of this research is to investigate the efficacies and potential applications of graphically 'mapping' the interrelated educational needs, aspirations, concerns, and other vital interests of students, their families, teachers, administrators, employers, and policy-makers, toward increasing the relevance, flexibility, and effectiveness of curricular in all domains of Higher Education. Benefits of increased efficiency, effectiveness, and agility for course planners and managers in all academic domains is anticipated. The paper summarizes the development of a mobile App to motivate such engagement in a collaborative curricular.

Keywords: Application · Collaboration · Curriculum mapping · Education · Japan · Policy

1 Introduction

Japan's 'National University Reform Plan' requires its universities to re-consider knowledge, skills, attitudes, values, and ethics in order to promote learning that is both global and active. Consequently, Japanese universities are having to thoroughly re-think their processes of planning, designing and delivering courses in Higher Education (termed New Diploma Policy) in order to meet these challenges. The paper is therefore an account of the development of a mobile curriculum application (herein referred to as an App) to motivate collaborative engagement in a New Diploma Policy implementation by key university stakeholders. The paper begins with an overview of Japan's desire to update its Institutes of Higher Education. One proposed solution of education policy implementation is curriculum mapping, and this is briefly discussed in the next section. To actively engage stakeholders in curriculum development and mapping, a mobile App has been designed by a multi-disciplinary team. The next section thus details the subsequent App design and development. Finally, the App's implementation is discussed, with recommendations for future use in supporting the aforementioned Reform Plan.

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2 Motivation

Recent policies to promote learning that is both global and active have prompted many Japanese institutions to thoroughly re-think their processes of planning, designing and delivering courses in Higher Education in order to meet persistent challenges: responding in new ways to learner needs; designing and delivering meaningful and flexible learning experiences; and varying assessment regimes. For instance, to implement its 'Overhaul of Organization and Overall Operations of National University Corporations' the Japanese Ministry of Education, Culture, Sports, Science and Technology (*Monbu-kagaku-shō*) is requiring all universities to reform their Diploma Policy to meet the needs of a changing demographic [1]. This 'National University Reform Plan' requires universities to consider knowledge, skills, attitudes, values, and ethics, and have been categorized into four broad classifications: Ways of Thinking; Ways of Working; Ways of Living in the World; Tools for Working.

However, there needs to be a holistic consideration which involves attitudes and values from a local and global community perspective; i.e. a pragmatic application of Ways of Living in the World. For instance, providing students with not only a real-life experience of working with innovative technologies, but also cross-cultural working with Japanese and non-Japanese students. The Higher Education Bureau of *Monbu-kagaku-shō* further state: "… cultivating true competencies to learn which enables students to live through the coming era will be impossible if we simply continue education in current styles" [1]. For academics, an appreciation of the changing curricular and education landscape within Japan is therefore required in order to formulate more enlightened curriculum policies at Japanese universities.

Curriculum delivery though presents many complex challenges. Like any act of design, curriculum design is usually based on some initial ideas. Yet because ideas about education are important politically and socially, the ideas that go into curriculum design are also usually politically and socially significant, and ideological. In other words, policymakers, educators, businesses, researchers, parents, pressure groups and other stakeholders interested in a curriculum all attempt to generate support for their own particular beliefs. For example, certain academics do not share the enthusiasm of businesses for curricular designed to promote post-industrial work; some parents don't possess the same passion for children's participatory cultures; some policymakers disregard educational research that cite benefits of experiential learning over rote-learning and standardized testing. Consequently, developing an education curriculum is a complex act of creative design. Add networked participatory media to the mix and curriculum design becomes more complicated. For instance in Japan, its assessment culture dismisses collaboration as a supplementary activity, rather than a core learning experience to be valued. In Japanese Higher Education much research has found little evidence of collaboration despite courses adopting learning designs that were intended to support it [2].

Still, we argue, education reform cannot be achieved simply by infusing present curricular approaches with greater interactivity and international flavor; the key is to reconfigure curricular from the bottom up, revealing and harnessing the 'productive diversity' [3] of interests and resources that the entire range of stakeholders bring to contexts and processes of education. Because opinions about education are consequential politically and socially, the ideas that underpin any curriculum are also inherently political, ideological and value laden. As previously mentioned, policy-makers, educators, students, businesses, researchers, parents and other stakeholders in education each seek for their own interests and agendas to be manifested accordingly in the courses of study with which they are concerned. By implication, the development of a curriculum must be approached as a complex, collaborative, inclusive process of pedagogical design. Williamson's assessment of the future of curricular confirms this notion: "Ideas about the future of the school curriculum are being generated both by government policymakers and outside the formal institutions of the state, by think-tanks, non- profit organizations, non-governmental and quasi-governmental organizations, charities and voluntary groups, and the philanthropic outgrowths of corporations" [4].

The fundamental design challenges, then, are to identify and then reconcile all of these diverse, often divergent perceptions, interests, and needs of different stakeholders. We contend that such a reconciliation cannot be achieved, much less operationalized, without a means of meaningfully, efficiently analyzing and, even more importantly, coherently representing (and continually re- presenting) these dynamically interrelated factors, such that the entire curricular ecology becomes momentarily sensible and comprehensible. Still, given such a means, the ecologically interrelated factors depicted on each resultant map must be interpreted with a view to positive curricular revision and pedagogical action, such that the positive potential contributions of stakeholders are recognized and the conditions for productive diversity are realized.

However, among the most typical and consequential shortcomings of educational programming and curriculum design is the lack of truly integrative, comprehensive attention to the changeable and changeably interconnected needs of individuals and the social, institutional, economic, and ideological circumstances in which each learner is eventually expected to thrive. The key to creating dynamically responsive, thoroughly relevant educational programs and systems is dynamically responsive access to thoroughly relevant information, which, we believe, appropriate use of a mobile App promises to provide. Rigorous, iterative investigation of a mobile App in varied conditions of actual implementation, as summarized here, is therefore needed before any firm conclusions may be drawn as to the curriculum App's efficacy.

In conclusion, an active learning curriculum prioritizes the development of the 21st century skills is needed to succeed in our knowledge and information–based economies. This can only be achieved through adapting the way of teaching, better interlinking aspects of syllabus content, and devising more holistic forms of assessment. The next sections are an account of the development of a mobile App to motivate engagement in such a collaborative curricular.

3 Curriculum Mapping

A curriculum is basically a plan for learning and a specification of how that learning occurs. It will generally consist of content, expected experiences, learning goals, and assessment. Curriculum mapping is recognized as a continuing process for orchestrating the scope and sequence of a curriculum to inspire coherence across grade levels, avoid unnecessary redundancies and provide teachers with timely feedback on curriculum implementation so that positive modifications can be made [5, 6]. As succinctly stated by Tee *et al.* "The purpose of any program mapping process is to allow cross referencing and support the integrity of the curriculum intent, thus ensuring that students achieve the intended learning outcomes with neither omissions of essential materials nor unnecessary duplication of student and staff effort. With a conceptual framework and supportive database, a coherent curriculum structure will be easy to assemble, manage and update" [7].

Pata *et al.* recognize that, "Curriculum design and management is one of the most challenging and least automated areas in education where semantic technologies seem to have unrealized potential" [8]. In their 2016 LTEC paper they highlight a number of researchers who have investigated technologies to update curricular, address curricular with particular standards, achieve links of competencies and resources, provide overviews, enable personalized planning, and facilitate collaboration in curriculum development [8]. One excellent tool is Curtin University's MyCourseMap. Tee *et al.* summarize MyCourseMap as, "… an interactive visual curriculum map that supports students in understanding the structure and integration of units in their chosen or prospective degree and assist them in appreciating the relevance of individual units of study to the profession or discipline" [7].

We posit that we have taken this excellent concept even further. Using an innovative, purpose-built Apple iOS and Android App (essentially a mobile learning support system), students and all other all stakeholders in any program of study or training will be able to dynamically co-construct rich, uniquely informative visual-verbal representations of the entire array of diverse considerations that bear on educational achievement and, most significantly, the complex connections and important contingencies among these considerations. In this collaborative 'wiki' approach, it is anticipated all academics and significant external stakeholders such as local industry entrepreneurs will 'have a say' regarding the development of a university's curricular to support active learning. This can then help promote and develop new pedagogies and assessment with updated content. Developing the tool itself along with associated concepts and interpretive practices is guided by a unique semiotic- ecological approach to curriculum design.

It is reasoned that a collaborative digital curriculum map (named a Learning Atlas App) created and constantly recreated in real-time by stakeholders will illustrate the connections (or not!) between subjects with the course syllabus. External stakeholders such as potential employers can contribute their expectations of university courses, e.g. particular programming skills, software knowledge, the ability to write and present sales plans, and special communication capacities. Thus informed, course managers and staff can then adjust their styles of teaching, the content they teach, and how they assess - in other words, the whole curricular - based upon the evidence displayed. This will help develop new pedagogies for active learning and 21st century skills within Japanese universities in science, technology, media and language educational contexts, as well as meeting the goals of Japan's aforementioned Reform Plan.

The next section will discuss the App's design and development.

4 Implementation

4.1 Plan – Do – Reflect

The research project comprised of three stages: plan – do – reflect (see Table 1). The project has a technology focus and an education focus. In short, a mobile App has been designed and programmed so that data from a secure server can be illustrated as a curriculum map. The curriculum map can be updated in real-time by Administrator access to the secure server. Education researchers in the university's Center for Meta-learning (CML) can then analyze the resulting map for syllabus strengths, gaps, misalignment, and repetition. The following is an account of the development.

Table 1. Plan – Do – Reflect

Stages	Technology goals	Education goals
PLAN	Input all syllabus data to our secure server	Plan the App design with a multi-disciplinary team
DO	Provide access to our database via a web browser for external stakeholders to update the syllabus	Design a curriculum map of the syllabus for use in an iOS App. Keyword search for 'learning pathways' in syllabus
REFLECT	Trial some suggestions for modification to university syllabus, and see how these impact upon curricular	Obtain feedback from academic colleagues

The university's syllabus data was first extracted from Excel and Word documents and added to an online Google Drive document. The data was arranged so that each column in the Google document table represented possible variables such as instructor, year, resources, and assessment criteria, that the App may retrieve. The document was shared with a translator who translated subject names and summaries from Japanese to English. The resulting document contained 184 subjects (the Rows) and 32 variables (the Columns).

In order to design and develop the App, a program with objects and associated attributes needed to be prepared. The required information had to be specifically determined, and then represented diagrammatically so that the multi-disciplinary project participants (educators, programmers and designers) were very clear about the project's outcomes and the App's focus. Leveraging the development of an earlier App [9], the objects, variables and attributes were then represented in a model – controller – view (MCV) pattern. These three interconnected parts separates data within an application so that the data can be presented in different ways to the end-user. The 'model' is the application data, the 'view' is the output representation in multiple formats, and the 'controller' accepts input and converts it to commands for the model or view. The syllabus data was then transferred to a dedicated server using the Java Eclipse program software. Eclipse retrieves specific data called a DAO (Data Access Object model). DAO's provide some specific data operations without exposing details of the database.

The database programmer then updated the online database containing all objects and attributes for content in both English and Japanese. Moreover, the data therein could be modified via secure access in a web browser (see Fig. 1). In addition, content keywords and learning keywords were provided for selection by users inputting syllabus data (see Fig. 2).

We also discovered that ‘curriculum’ in Japan is known as the ‘syllabus’ (シラバス) due to a translation from English to Japanese where ‘curriculum’ and ‘syllabus’ are deemed synonymous. In English, ‘curriculum’ and ‘syllabus’ are distinctly different: ‘curriculum’ refers to course content, the teaching pedagogy and the form of assessment; ‘syllabus’ refers to the course and subjects’ content only (i.e. what is being taught). This did not slow down the development but throughout this paper some images show syllabus while our explanation refers to curricular.

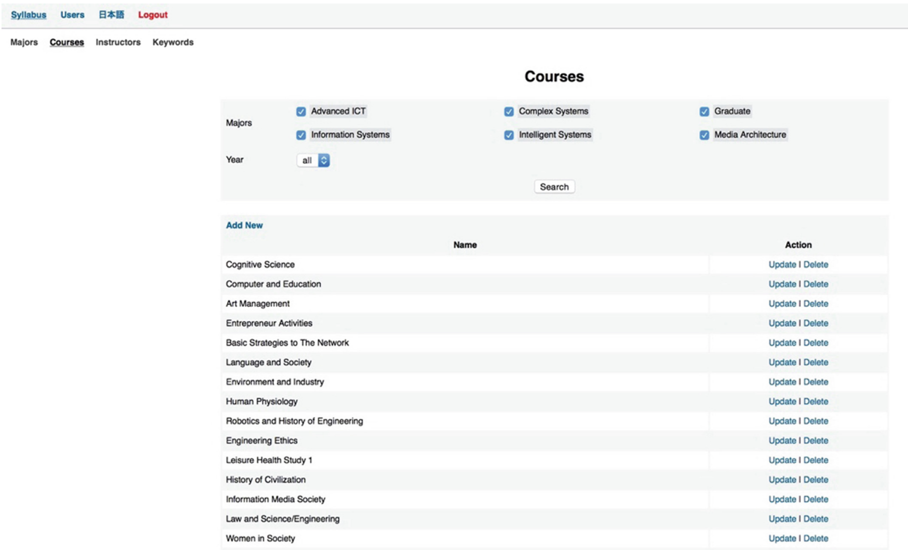

Fig. 1. Course list in database.

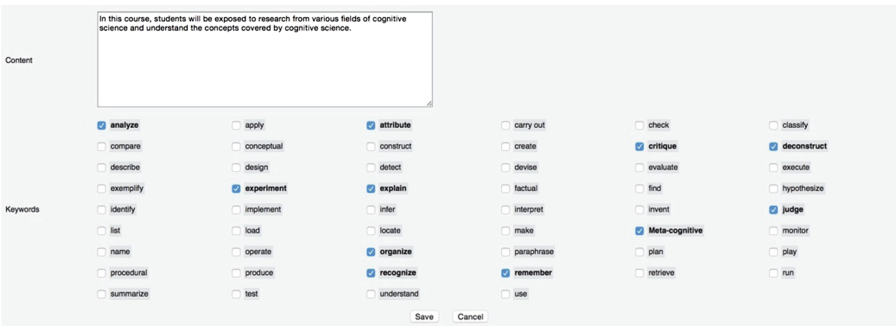

Fig. 2. Learning keywords list in database.

4.2 Application Design

The App is developed using HTML5, JavaScript, and CSS3. The App programming is undertaken using Sublime Text [10], a text editor for coding on a Mac OSX computer. In order to develop dynamic views in the web-based application, the AngularJS [11] and OnsenUI [12] toolsets are used. Monaca is used for debugging. Monaca allows for Apps to be developed cross-platform in the cloud [13]. To develop the dynamic map visualizations, the D3.js JavaScript library is used [14]. Using these combination of tools has the advantage of developing one-time and being able to export to multiple platforms such as Apple iOS and various versions of Android. Moreover, it illustrates the 'ways of working' commonplace of independent programmers not confined to one corporate technology tool (e.g. Apple's XCode or Google's Android Studio).

In its initial design stage, after determining the App's variables, the interconnectedness between subjects of study – essentially the design of the curriculum mapping – were initially represented in spider, tree and tabular displays (see Fig. 3).

Each had it merits but it was decided to progress with the 'tree' design for courses and their included subjects as this design was viewed favorably on an iPhone 5S and iPad using Apple's XCode Simulator (see Fig. 4).

For example, in Fig. 4. a student wants to know more about the classes undertaken in Year 3 at FUN (the acronym for Future University). The class subjects are listed and the student is attracted to Human Interface. Tapping on this subject presents additional information about the subject's content, the instructors, the particular course, and content keywords. Learning keywords was an option added at later date. Additional information regarding subjects that contain the primary keywords is also provided as links.

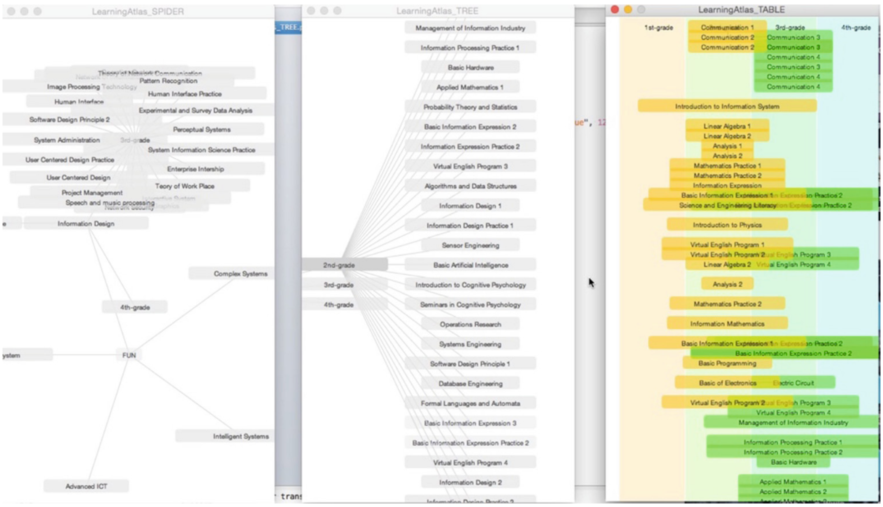

Fig. 3. Spider, tree and tabular displays of mapped subjects.

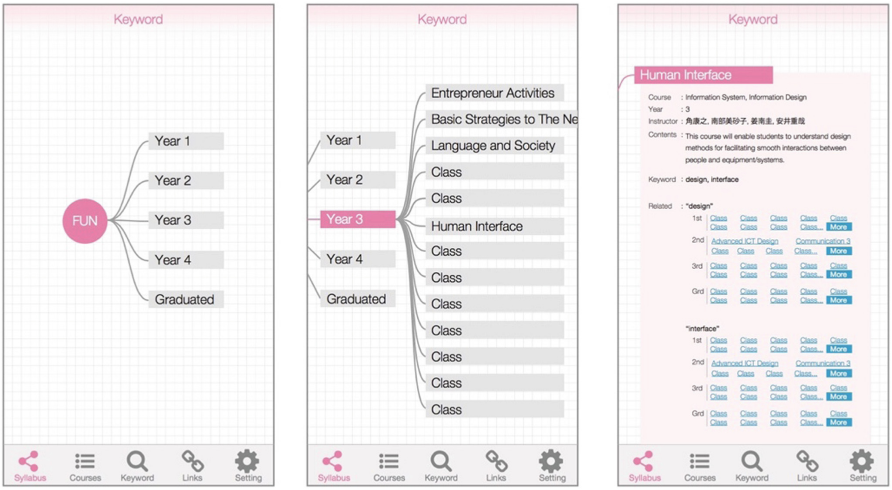

Fig. 4. Design for display of courses and subjects.

4.3 Keyword Searching

We also had to consider the display of the results of keyword searches. To this end our decision was influenced by the excellent Wikilinks App [15] and our previous experience programming our early iteration of the App [9]. The 'spider' design was chosen and subsequently programmed (see Fig. 5). Based on user feedback of our first App, which also contained a 'spider' display [9], the dynamic graphical nodes were easy to view and map. Links across different nodes presented a semiotic interpretation that

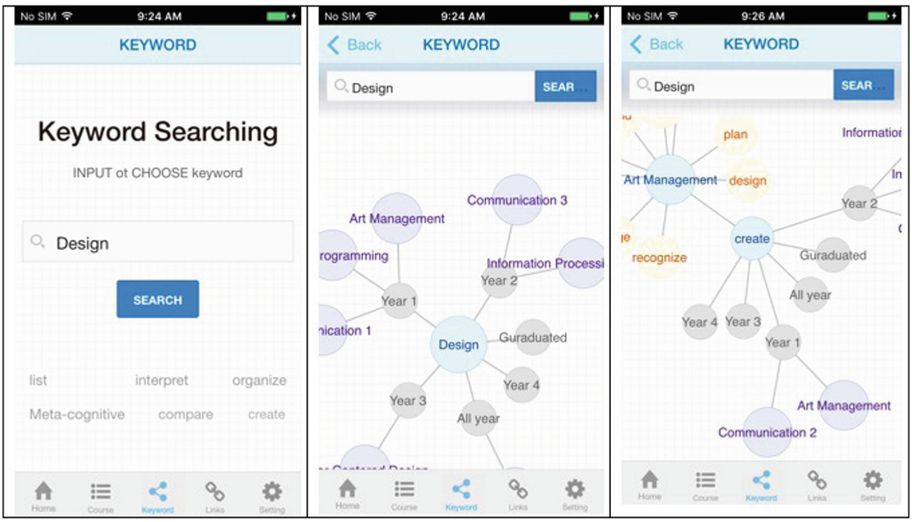

Fig. 5. Design for display of keyword searches.

users were not only attracted to but could also quickly visualize the connections between subjects. An example is provided in Table 2 and Fig. 5.

Table 2. How to use keywords to search the syllabus in 3 steps.

step 1: type a search term; e.g. design
step 2: click Search
step 3: let's look at the resulting map.
Level 1 node = keyword
Level 2 node = year of study
Level 3 node A = subject
Level 3 node B = associated content & learning keywords
Tapping any of these nodes will lead to further information and additional nodes

For example, in Fig. 5. a student is interested in 'design' and has typed the keyword. A corresponding number of subjects for each year are then shown as nodes. From the selection, the student is interested in Art Management so taps the text. This provides additional keywords for the student to consider. By tapping the text a second time, the student will be taken to the subject information page detailing the subject's content, instructors and objectives. The student can also select another keyword such as 'create' and is then shown additional nodes of subject by year that include both keywords.

The menus of the App interface were initially agreed to be Syllabus - Courses – Keyword – Links – Setting. Also, the App logo was designed by a student designer consisting of the three letters of FUN plus four colors representing the four courses at Future University.

4.4 Application Update

With the syllabus data accessible from the server, the programmer could continue developing the App while other team members regularly updated the syllabus content. Any updates to the syllabus could be undertaken by inputting data directly to the server thereby not interfering with the development of the programming of the App. In time the App began to take shape with course lists per year, course information in English and course details in Japanese. It was also decided to summarize the course details (termed 'Theme' in Japanese) to the amount of text viewable in one iPhone 5S screen size. After many months of development the App was tested on the iPhone Simulator on the programmer's MacBook. Users could select an English or Japanese interface and content through the Settings menu; irrespective of their device's primary language setting.

After feedback from an earlier iteration, a number a minor updates were introduced (see Fig. 6). The menus were changed to Home – Syllabus – Keyword – Links – Setting. A list of useful website links were added. It was also found that some keywords such as 'design' and 'create' occurred in so many subjects that the map became overwhelmed and there was not enough window space to show all the links. The subject keywords had to be curated to be more specific to each particular subject. In addition, the Graduate school courses were added to the server data. As the initial stages in the determination of the variables was absolutely clear, adding the Graduate school information was seamless and quick. Due to our 'data-in-the-cloud' approach, syllabus data can be updated in real-time without the need to specifically update the App itself.

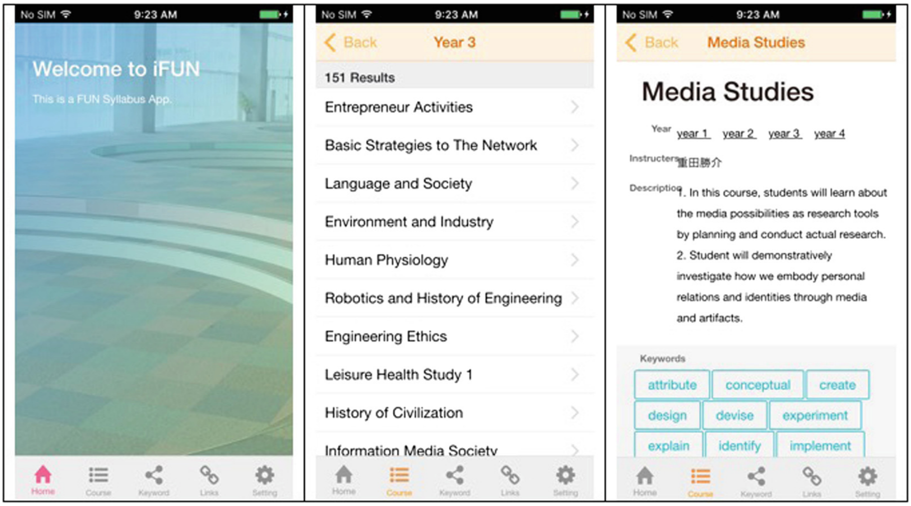

Fig. 6. App interface.

In addition to the 'search and map' feature, the convenience of the App enables students to have immediate access to web links such as local information, bus timetables and Meta-learning Lab peer-tutoring schedules in Japanese and English. Students can quickly access and read about courses and, with personal academic support, student 'learning pathways' can be developed, thereby empowering students to be motivated to take ownership of their career development. Moreover, the App has proven cost-effective as it has negated the need to print hundreds of syllabus books (often up to 200 pages each).

Access to update the server is restricted to selected users at present. A user such as an academic or a parent or a member of the business community who wishes to offer some input to the curricular can request an account and password. The person then has access to the main database. Subject goals, summaries, assessment criteria and keywords can be amended. New subjects can also be added in both English and Japanese. However, this is not the primary database of the university's curricular, but the database associated with this project and its App. The primary database is secured behind a university firewall with limited access by selected managerial and administrative staff only. It is hoped that in future, as our App and its associated education concept gains traction, that a more collaborative curricular be activated. To enable this we need to oversee this collaborative App for at least one year and then analyze the input from interested stakeholders. At that time we will then undertake a fine-grained analysis of the aforementioned 'ecological' representations of curricular-in-action and the situated, participatory processes through which these maps emerge and evolve.

5 Conclusion

The paper has summarized the design of a mobile App to motivate engagement of university stakeholders in developing a new curricular for the 21st century. The multi-disciplinary approach has led to a successful outcome which will prove beneficial to all current and future students and staff of the university. The regular meetings and subsequent action items provided clarity and transparency. Technological obstacles were overcome as a team whether they related to code, to server-side variables, to interface design, or to syllabus data. However, the current syllabus format is not standardized so each subject is summarized in different arrangements. Some subjects simply summarized the main goal, some subjects listed weekly topics, and some subjects included assessment criteria and course resources. Particular to this project, it was found that less than half the courses listed any keywords. Therefore, it will be necessary for course leaders to laisse with their academic staff to create a common syllabus focus, and certainly include key content and learning words. Moreover, bureaucratic obstacles remain. Despite the directive from the Japanese government for its National Universities to evolve and be more relevant to a 21st century society, the university-wide adoption of such a unique, open-ended collaborative tool has been stolid. The university's new Diploma Policy failed to adopt the 'learning keywords' approach included in our App development. Nevertheless, we contend that the cross-cultural participation (Japan and UK) in our project successfully facilitated the development of particular skill sets, applied knowledge to innovative situations, empowered positive attitudes to active learning, influenced emotional values associated with care and understanding, and promoted ethical considerations of the impact of technological developments. These represent the 'ways of working' so desired by Japan's Higher Education Bureau.

The App is free to download for Apple's iPhone and iPad devices at http://apple.co/2iazxN6 and Android devices at http://bit.ly/2iaGHB3.

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Change Management: Digital Transition in the Public Schools of Georgia

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Abstract. This study explores managing educational change in Georgian public schools and attempts to take an in-depth look to “change in practice”. We used grounded theory to analyze qualitatively the interviews from 3 Georgian schools. Schools were chosen from the innovative schools cluster from the first phase of 15 Georgian schools. The First phase of the research disclosed change management variable as the biggest determinant to cluster belonging. The second phase of the research investigated the characteristics of the change management on two different stakeholder groups: school principals and teachers. The data was coded using initial and focused coding to conceptualize an analytic narrative. The findings suggest that innovative schools in Georgia use ICT as the instrument of change management to distinguish themselves in the educational ecosystem of public schools. Innovative schools build transformative niches of digital innovation to create their schools’ digital identity with and around ICT. For principals the change management vehicle is ICT as an administrative tool, while teachers use shifting their roles to being facilitator in ICT-rich activities. Both transformative niches are still not orchestrated and collaboratively managed in the observed schools.

Keywords: Change management · Digitally enhanced schools · ICT policy · Technology-enhanced learning

1 Introduction

Dissemination of innovation is an exercise of change and requires understanding of change management [4]. Change has been defined across many disciplines. The most frequently applied model of change is Lewin’s 3-step model that characterizes change through unfreeze-transition-refreeze cycle [12]. It describes creation of the right conditions for the change to occur, the process of transitional “journey” and re-establishment of a new place for stability. Some scholars criticize the model for leaving out temporal dimensions of organizational change and proposes additional dimension of sequence, timing, pace, rhythm and polyphony [1, 10]. Lewins‘s model is considered irrelevant for the organizations operating in today’s volatile, Complex and uncertain environment. It represents Diagnostic Organizational change where leaders are expected to produce clear visions and propose set of goals. Leaders in such organizations collaboratively collect and analyze data and guide planning and actions.

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In response to the complexities of managing change in turbulent and ambiguous world dialogical organizational mindset emerges that focuses on “engaging people in self-reflection and interaction, rely on self-organizing processes and emergence, and seek to achieve desired outcomes by changing the conversation” [2].

The knowledge on how the schools are changing in the complex and dramatically fluctuating world could be a powerful instrument for the improvement of education strategy. Individuals or the organization change either voluntarily or enforced, that can result in accomplishments and professional growth [5]. Implementation of educational change involves “change in practice”. But what does it exactly mean? Fullan suggests looking at different level of change, e.g. school, teacher, district level [6].

In our study we suggest to look at school level change and consider teacher and principal’s subjective viewpoints to construct the meaning how schools manage change, to develop the understanding how the change is coped at the school level to form the digitally enhanced learning ecosystem. The study is the 2nd phase of the earlier research on the difference of digitally enhanced and less innovative schools [8, 9]. Change management was found the biggest determinant of the variance between the 2 clusters. With the present study we aim to investigate on this end and explore the deeper understanding on the digital changes reflected in the learning setting.

2 Methodology

2.1 Context

This study is the second phase of the research conducted in the public schools of Georgia [8, 9]. Georgia began modernization of general education system by investing in ICT infrastructure and capacity building in 2005. All the schools have been equipped with computer technology and Internet. The ratio of desktop computers located in computer lab reaches 30:1. Ministry of Education and Science of Georgia provides free ICT training for teachers. The trainings focus on methodology as well as developing ICT skills of the teachers. From 2011 Georgia is realizing an ambitious program of Netbooks for First graders. In the bounds of the program all the first graders and their teachers receive netbook, called buki, on the first day at school as the gift from the state.

On the first stage of the research 15 schools were chosen on the basis of geographical indicators, school size and school ICT activity. Analysis revealed 2 clusters of the schools: digitally enhanced schools and less innovative schools. We analyzed data across the grid of the digital services developed in advance [8]. Change management was the biggest determinant of the school belonging to the cluster.

Our 2nd phase of the research aims to dig deeper on the change management determinant and analyze how schools manage the change, what is the process undergoing, what actually changes in school and classroom practice, how schools embrace change management. Our goal is uncovering the nature of “change in practice” in Georgian public schools. We selected 3 schools from innovative schools cluster that showed the most interesting practice from the first phase of the research. Below we will refer those 3 schools as city, town and capital city school.

2.2 Participants

Interviews of 3 principals, 3 information managers and 6 teachers were used for the study. 2 teachers, 1 principal and 1 information manager were interviewed per city, town and capital city schools.

2.3 Procedures

Interviews of the participants were recorded and transcribed. As the data was already collected it addresses not only research question but the grid of the services developed earlier for the first phase of the research. The grid comprises three educational domains of: digital infrastructure, learning facilitation and change management. Each domain has subdomains. 6 subdomains represent our particular study of interest – change management: teacher professional development, teacher support, sharing and cooperation, strategy and planning, monitoring and analysis, incentives and motivation [8]. Guiding questions focused on technology-enhanced learning processes and the changes that occurs at school.

2.4 Applying Grounded Theory

We selected to use grounded theory methodology based on the aim of the study, that is description of the change process and building the theory [13, 18]. Grounded theory is a systemic inductive inquiry [18] that includes simultaneous involvement in data collection and analysis, constructing codes and categories grounded in data, therefore advancing theory development on each step of data collection and analysis using constant comparative method [3, 7]. We hereby note that we construct grounded theory through our past and present involvements and interactions with people, perspectives, and research practices [3].

In the proposed study we consider the trajectories how schools embrace management of change within innovative practice implementation activities context. Comparative analysis of interview data enables to enhance understanding of the process of change and to further advance the understanding of the phenomena.

2.5 Data Analysis

The data was first analyzed with initial coding to study fragments of data closely for their analytical import. It helped to separate data into categories and see the process. The initial codes that made most analytic sense to categorize the data were selected as focused codes. Through the process we compared the data with data and with codes. Codes were developed into categories and subcategories exploring on the links among them [3].

3 Results

Results of the "change in practice" in Georgian public schools using ICT as a vehicle of change are presented based on the cumulative information from all the participants. We construct the results based on the participants describing the processes undergoing in their school and classroom settings. We will discuss three broad categories and relevant subcategories that comprise our understanding of change process. The categories are: Building school identity around ICT, emerging changes, and driving issues and drawbacks.

3.1 Building School Identity Around ICT

The category is represented by five subcategories: building transformative niches, imposing pillar activities, patterns of teacher grouping, leadership and ICT as an administrative tool. Each subcategory has the number of focused codes that emerged from the data. The codes and their relationships formed categories and subcategories of the phenomena under the study.

3.1.1 Building Transformative Educational Niches

All three schools decided to use ICT as a tool to tackle the challenges schools have. All schools see ICT as a tool to develop their schools as distinctive educational transformative niches within the bigger educational ecosystem provided by public Georgian schools. The capital city school puts its effort to build brand around specialized learning and ICT. Town school focuses on empowering school curriculum with ICT-enhanced projects. City school distinguishes in building e-management services for administering teacher portfolios and communication.

3.1.2 Imposing Pillar Activities

Schools follow the same pattern to impose the core activity for the implementation of the digital innovation at school level. The innovative activity itself has mandatory character to be involved in. Though they are different in each school. Capital city school introduced teacher e-portfolios. Teachers create their e-portfolios and present to school administration for the assessment of their work. ICT utilization for the lessons presented in the portfolio is required also. This is how school justifies and sees technology in learning.

City school organizes digital innovation around e-management and using cloud services. For town school the pillar activity comes to ICT-enhanced project based learning.

While capital city and city school is inclined to use ICT more as an administrative tool the town school shows more evidence to use ICT as a natural learning tool used in the educational process apart from administrative processes.

3.1.3 Patterns of Teacher Grouping

In all schools principals distinguish two camps of teachers, those of using and not using ICT in teaching. Despite the same pattern of the grouping the composition of the camps are different. In a capital city school, principal's "allies" comprise the camp of ICT users group. She begins all the initiative with that network of allies. This is more of division by personal characteristic, motivation and certain skills. As she describes she came in the school, noticed certain teachers who were innovative and made the team out of close-minded people to rely on further innovative initiatives. For town school that camp divides between structural positions: primary school teachers who possess state-granted Bukis and middle/high school teachers. As principal indicates primary school teachers are more trained by centrally managed trainings and have better ICT skills and readiness for innovative teaching practice. City school divides teachers between certified[1] teachers as ICT users and all others as non-users.

3.1.4 Leadership

In all schools principals are clearly distinguished leaders of the process and decision-makers. Schools have board of trustees as imposed by the law, but it has formal character. All the principals openly told that decisions about the change management are thought and made by them, then discussed with teachers. None of them mentioned any initiatives or amendments coming from the teachers. Only Capital school principal said teacher quality criteria had opposition from teachers, though it can be explained by the tough consequences the process is followed. Teachers know they will have to quit their jobs if not met the criteria they are agreed upon with the administration. All of three principals wording strongly emphasized their dominance in decision-making. In city school principal even decides the winners of the contest, and students wait for her to have time to make decision.

3.1.5 ICT as an Administrative Tool

Transition takes place mostly in ICT enhanced administrative tasks. Schools seem to copy ICT enhanced administrative tasks from other workplaces. City school has a well-developed structure of e-management on cloud services via Google drive. Capital city school manages administrative tasks digitally also. Less top-down initiatives comes on the utilization of ICT in educational process. It is mostly decision of the teachers while ICT as an administrative tool is imposed to be used by everybody. These two sides are not interconnected. It still seems to have a long way to go to change the learning environment itself, the roles of the student and teachers does not seem to change steadily.

3.2 Emerging Changes

Emergent changes is the second category that our data revealed. It covers the subcategories that describe the actual changes taking place in the classroom setting in terms of technology use, teacher and student roles, as well as methodologies. The category links six subcategories of: stages for technology use, purposes for change,

[1] In-service teachers pass examination and get certificate to get involved in teacher professional development scheme developed by the Ministry of Education and Science of Georgia.

resources for change, methodologies of change, collaboration and e-communication, general impression of change.

3.2.1 Stages for Technology Use

Not surprisingly all the participants of the study use technology in the learning process. They were selected from the innovative school cluster. However the range of the use as well as the content and approach differ from each other. Based on these characteristics 5 levels of technology utilization is developed from the data separately for the teachers and students as shown below in the table (Table 1).

Table 1. Stages of technology use

Stages in teacher use of technology	Stages in student use of technology
1. Using ready made resources/information retrieval	1. Using for information retrieval/introduction
2. Reusing ready made resources/fitting to personal teaching needs	2. Working in existing file
3. Digitizing existing resources/creating from scratch	3. Reusing already existing file
4. Creating technology enhanced resources from scratch	4. Creating from scratch
5. Collaborating to add new knowledge to existing digital resources	5. Adding new knowledge to existing file

3.2.2 Purpose for Changes

Innovator teacher differ from other teachers in utilizing technology purposefully for their educational needs. Even the complexity of the technology use vary, the purpose range goes from simple to complex. Our participants use technology for the **introduction of the information, topic or concept**. They help students to **memorize information** with digital tools, Georgian language teacher at town school creates digital games in various apps and lets students play to help them memorize details from the biographies of the writers. Another purpose for using technology is **simplifying the concepts students find hard to understand**. Physics teacher at city school applies virtual labs to visualize and practically showcase concepts to the students, help them understand and motivate in that way to love the subject. Here comes another strategy of **digitally visualizing material otherwise impossible to represent**. Chemistry teacher and physics teacher emphasize this strategy in their teaching with technology. Dependent on the subject the strategies applied are also **reading strategies** for primary school teachers and literature teacher like sentence construction, word identification, using commixes for text recovery, using animations for reading with pauses. Technology is successfully used for **writing strategies**, e.g. weblog diaries. Teachers indicate that they are changing their practice to use technology for **deepening understanding on the subject, concept or topic**.

3.2.3 Resources for Change

This subcategory is closely linked with purpose and methodologies subcategories of change. In Resources we describe digital resources or tools, while in methodologies we imply to the processes that are necessary for the change. The most frequently referred resources was presentations, Youtube 3D presentations among them. Teachers use videos, animations, games, subject oriented apps, MS office and various apps to create resources. Teachers give task to students mostly to prepare with MS Office, sometimes with subject-oriented apps like Geogebra or virtual labs.

3.2.4 Methodologies for Change

Teachers follow certain methods that differ in certain cases and are the similar in some areas. All the teachers, except primary school teacher where every student can use bukis, **give technology-enhanced tasks for home**. This is the only way to let students individually work with technology. Schools do not have enough technology and they do not support bring-your-own-device approach.

Another similar pattern for all the participant teachers was **involvement in technology-enhanced projects, international projects among them**. Teachers are active in **extracurricular activities and competitions**. Prominent example is chemistry teacher in capital city school who set up chemistry club as the part of international project.

Teachers acknowledge **student skills in ICT** and collaborate with them to create resources. This is one of the projecting processes that are changing in the teacher-student relationship with the help of ICT.

ICT is separate subject in 1st, 5th and 6th grade In Georgian schools. So one of the methods coming out of the data is **integrating subjects with ICT lessons**. Teachers also emphasize the opportunity of **authentic learning** technology creates. History teacher recovers the battle scenarios with students with the help of technology. Teachers use opportunity to **create hands-on resources**, e.g. maps for the specific educational task.

Chemistry teacher from capital city school initiated **research on ICT impact** on teaching. She measured and compared academic results of 2 classes with and without technology enhanced learning. Her findings show that students with technology enhanced learning showed deeper understanding in chemistry, however she had to wait for the students results to be visible as she says.

3.2.5 Collaboration and E-Communication

Collaboration in our data was outlined on 4 levels and each level had certain patterns. The levels are: students, colleagues within school, colleagues out of school, colleagues internationally. Collaboration with students is mainly marked with filling ICT skills that teachers themselves lack, e.g. history teacher asked students to create videos on the scenarios developed by her.

Collaboration with colleagues within school has 3 patterns: (a) **sharing resource**: This pattern lacks interaction and is rather one-sided communication. The codes under this subcategory were: colleagues using ready digital resources, sharing at the subject department, sharing experience. (b) **Collaborating**: this pattern characterizes with interaction. The focused codes under this subcategory are: getting (appreciating) feedback, colleagues making re-use of existing experience, reflecting on activities with colleagues, offering ICT skills/solutions/Technology-enhanced learning methods to colleagues, planning/modifying project ideas with colleagues, collaborating with colleagues from subject department. (c) **Mentoring colleagues**: teachers hold training modules for colleagues on their initiative, plan a workshop to introduce tool/method, organize meeting to offer ICT solutions.

Colleagues out of school has face-to-face or online communication, it is characterized with less interactive communication. (a) **Face-to-face one-sided sharing of resources**: it is mainly described with sharing experience at the conference; (b) **online one-sided sharing**: Resources are shared though it is not interactive process and only has the option of sending and receiving of resources. The codes under this subcategory are: sharing resources with collaborators (already known colleagues), and sharing resources on personal weblog, (c) **mixed**: collaborating with subject teachers from other schools, helping collaborators with ICT skills.

On an international level teachers are interacting with colleagues online to plan, share resources, implement projects.

E-mail and social media are the most powerful communication tools the teachers use with students, colleagues and parents. Social media is the channel they get the information from in the changed environment. They look for TEL new experience, and get news from social media. Activities teachers undertake are the same while the means and process change. Math teacher says she receives mid-term reports of the project via email and sends feedback to students by email. Majority of participants share comments on closed facebook group, they share exercises and discuss everyday logistics on social media with students. Teachers communicate with colleagues via Internet. Intensity of the communication is different. They share resources on personal weblog for less interactive communication and communicate on social media groups to exchange information more interactively. Even the scale of collaboration changes with social media. Teachers share experience through international learning web-community.

3.2.6 General Impression on Changes

Interestingly teachers describe their impressions on the overall change images in the school setting. The data revealed negative school level codes, neutral, positive personal, positive school level indicators. Teachers did not mention factors that would describe personal negative indicators. History teacher at city school described the problems other schoolteachers have with administration on initiating innovative approaches. As she describes often **responsibility on technology damage** is put on them so teachers prefer not to initiate any technology-enhanced activity. However, she does not notice this at her school. All the teachers indicated that **not all their colleagues use technology in teaching**. One of the reason to oppose technology-enhanced learning is **lack of time**. Primary school teacher, who works as ICT trainer at the Ministry of Education and Science at the same time, states that teachers have challenges **to independently work on TEL**, and the **challenges mostly refer to topical than technological part of the teaching process**. Teachers **lack ICT competencies despite participating in centralized training**, as study participants notice their colleagues prefer to **get back to training** (guided practice), then **develop gained ICT**

skills independently (independent practice) or use acquired skills in practice independently.

Noticeably our participants do believe that **teachers are doing what is required from them**. We put this code under neutral school level codes. They refer to top-down initiatives more then bottom-up actions. Surprisingly even innovative selected teachers do not know school action plan, in best cases **school action plan is formally introduced by administration**.

As expected all participants declare they **use ICT more intensely compared to other teachers**. History teacher at city school notes she is **looking for the next stage in ICT expansion**. Despite being initiator of innovative projects and approaches, she looks from top-down guidance for further directions to change her practice. Among positive school level factors teachers indicated **principal's ICT skills** and **basic ICT skills being a natural attribute for school actors**. A controversial topic seems to be aged teachers' ICT skills. Some of the participants refer to teachers' age as the reason for low ICT competencies, on the other hand some participants described as a positive experience that **aged teachers work with technologies** in their corresponding schools.

3.3 Driving Issues and Drawbacks

In this category we collected the codes that to our perception indicates to the factors and processes supporting or hindering the change in school. We delineated 4 subcategories of: supporting factors, challenges, necessities, developing skills.

3.3.1 Supporting Factors

Data revealed 4 modes of supporting factors: administration, family, school information manager and students. The codes connected to administration mode supporting factors are associated with **appreciation of trust, arranging infrastructure and managing logistics to use technology, recognition of individual success with technology**. Not the less is the role of school information manager. All three schools in our focus have active information manager teachers express a hope in. Teachers indicate **motivated information manager initiating activities and events** as a supporting factor.

Our participants distinguish with high motivation in implementing technology-enhanced learning in their classroom. Prominently history teacher from city school notes that **their motivation concurs with the students**. All the participants signify the high **motivation of the students** then technology is involved in the teaching. In addition they declare **students having high results with TEL** emphasizing at deeper understanding on the concepts and topics of the subject. These codes together with **students having good ICT competencies** comprise supporting factor subcategory for students' mode.

Some participant teachers also indicated **family members support** in technology implementation. History teacher prepared first hand-on map with her brother that showed her the necessity of the technology and ripe the decision on the technology use. Physics teacher asks for help to her children to prepare digital resources.

3.3.2 Challenges

We did not notice particular emphasis on the challenges from our participants. To our observation more teachers use technology less they focus on infrastructural troubles and focus on methodological issues. The data showed 4 modes: personal, institutional, mixed and cultural. In personal mode the most significant code refers to **communication with parents**. Primary school teacher from town school reflected on her own practice as not having stable communication with parents. History teacher at city school says she does not have enough communication with parents to explain the necessity of technology enhanced learning to gain their support in the process. Another personal level challenges were connected to fear: **fear of technology**, having **complex to be humanitarian** and not being able to work with technology, and **fear to lack control over students** in technology enhanced learning. History teacher is also concerned about **planning process in TEL lessons** and meeting desired results. Teachers are very cautious to speak about the **lack of competences**. In this regard Georgian language teacher at town school mentioned lacking competence to use buki classroom management program. However she felt easier to talk about it as buki trainings are assigned for primary school teachers. The skills she asked for would be a supplementary for her.

On the institutional level teachers often refer to the **lack of time** for the technology enhanced lessons and projects. Especially with the rising demand on the test results, teachers are **diminishing TEL for the sake of tests**. TEL requires additional time for planning while teachers have **inappropriate workload and salary for TEL**. School computer labs are occupied with ICT lessons, and teachers have to **compete for technology resources**. Teachers are concerned about the **student number for TEL classes** that raises TEL class management issues. Very interesting topic arises also about the **ICT integration in subject teaching**. Teachers are not certain if they can use lesson period for teaching certain app.

The schools in our focus are located in poor neighborhoods with the students from socially disadvantaged family. As participants describe the level of parent education is lower. Accordingly **parents do not encourage TEL process**. They prioritize paper-based education. History teacher has to ignore the initiative of using Edmodo educational platform because of discouragement from parents. Another big cultural level challenge that hinders TEL implementation process as participants describe is **ICT being perceived as entertainment**. Not surprisingly teachers find **first reaction to the innovative approaches negative**, they have to tackle with those first reactions. The only allies are the students who are always glad with TEL initiatives. On the students sides the most prominent problem with TEL classroom is **integrity**, teachers have to seriously work on that issue, though they have progress as they declare.

There are some codes in the challenges subcategory that involve several levels, so we decided to put them together in the mixed level mode. These challenges are teachers **not remembering school action plan**, and **students getting bored with certain technology resources**, e.g. PowerPoint slides animations.

3.3.3 Necessities

Participants were very reserved to talk about the necessities. They talked about **building communication channels with parents, building communication with**

colleagues outside school, asking for free computer classroom for more frequent technology use and **updating technology skills**, e.g. to create games for lesson.

3.3.4 Developing Skills

Data shows 5 patterns of how our participants develop the skills to be able to change their practice for TEL. They either refuse to participate in centralized trainings and develop the skills independently based on their own needs. Or they participate eagerly in all the trainings and in parallel they search for new apps and subject-oriented tools independently. History teacher prefers developing her skills little by little at this stage and do not have training desire any more.

First pattern associates with **developing skills independently**, having little discoveries on her own, searching for new programs, reflecting on own teaching practice. 2nd pattern is **developing skills through centralized trainings**. Teachers decide to upgrade their university education with centralized training/internship, participating in subject oriented training, e.g. chemistry teacher participated in managing high-tech chemistry lab and TEL trainings in the bounds of international project. 3rd pattern points to the preference of **colleague's help**. Teachers ask either information manager or colleagues for help. E.g. Georgian language teacher asked primary school teachers to help teach her buki classroom management program. This pattern works when teachers need hands-on help on a certain issue. Our participant teachers tend to **use online resources** and this created the 4th pattern of the subcategory. They get information on new apps and softs, read news actively from social media. The 5th pattern associates with **family members**. Teachers use family to get hands-on help on certain issues while working on digital resources.

4 Discussion

In this qualitative study we focused on the phenomena of digital change that school undertakes in the digitally enhanced innovative learning ecosystem. The model we constructed involves teachers and principals perceptions and representation of the processes. Accordingly the model depicts how the school manages transition on the school level and what actually changes in the learning settings (Table 2).

In the educational ecosystem schools use ICT as a vehicle to build transformative educational niches that carry their identity. School leadership tends to impose ICT utilization for administrative purposes while somehow neglecting it as an educational driver. Utilization of ICT in the classroom setting is more bottom-up initiative by the innovator teachers. School administrations in all respective schools impose pillar activity by which administration tries to diffuse technology in school. These activities are quite solely implemented.

Change in the role of the teacher and student is more prominent with our participant teachers who use technology-enhanced learning in their classrooms. Students are more active in planning their learning. However, Teachers only introduce learning goals, students are not involved in designing process. Students have more active part in developing assessment criteria for their own learning. Teachers first introduce the rubrics to the students and then develop it with them. Teachers are changing their role

Table 2. Change aspects according to sub-categories

	Categories and Sub-categories	Change aspects
1.	*Building School Identity around ICT*	
1.1	Building transformative educational niches	Using ICT as a tool for building transformative educational niches for schools in the country's educational ecosystem
1.2	Imposing pillar activities	Involving technology in innovative core activity
1.3	Patterns of teacher grouping	Forming the groups of technology users
1.4	Leadership	Supporting and expanding ICT activities on school level
1.5	ICT as an administrative tool	Imposing technology more for fulfilling administrative tasks, disconnected from actual teaching with ICT
2.	*Emerging Changes*	
2.1	Stages for Technology use	Expanding the range of technology use both in teachers and students work
2.2	Purpose for change	Setting purposeful educational meaning for technology use
2.3	Resources for change	Using more complicated tools
2.4	Methodology for change	Applying ICT-enhanced project-based learning, Performing individual technology enhanced tasks using students' home computer
2.5	Collaboration and e-communication	Using e-communication to collaborate with students, colleagues and parents
2.6	General impression of change	Teachers' expectation towards top-down guidance for visions in teaching with ICT
3.	*Driving issues and drawbacks*	
3.1	Supporting factors	Getting support and appreciation from administration for TEL implementation
3.2	Challenges	Involving parents in TEL; managing TEL classroom
3.3	Necessities	Building communication channels with parents (on the benefits of TEL) and colleagues, computer classroom for TEL
3.4	Developing digital skills	Developing skills independently, using online resources.

from being conductor of the process to more being a facilitator. According to the description the facilitator role is more noticeable then participating in ICT-based projects, while the lessons are still conducted with teachers leading the process.

Change occurs in the activities offered by our participant teachers. Technology enhanced activities change not only the means but also the content of it. This change is reflected in Emerging Change category in the subcategory of stages of ICT use, methodologies of the change. Students are changing into more producing the educational product with technology than mere users of teacher-produced resources. Activities with technology with our participants are more inclined to deepening the understanding on the subject. Students create resources that are then used by the teachers to teach their peers. Teachers say students reported they remember and understand those materials the best. Passing the knowledge artifacts from one social entity: individual, group collective – to another allows these social entities to improve and extend that knowledge by refinement and the inclusion of new properties. Thus, knowledge artifacts serve as the emergent international resources [17] that mediate between individual learning, group cognition and organizational knowledge building [14–16]. It changes the format of knowledge, e.g. implicit to explicit, practiced behaviors to verbally or visually communicated experiences [11] Change occurs in collaboration patterns. All our participants actively use e-communication with students and colleagues, some involved even parents. It alters not only the form but also the content of the relationship, changing the communication scope. Majority of the participants reported their involvement in international projects sharing experience via local and international learning community.

Changes are often responses to students' demands. Moreover students are initiators of the process. Then we talk about bottom-up initiative we often consider teachers' initiatives, however technology rises the conditions where students are dictating the process. Giving feedback on social media closed group was the process that emerged from students. Math teacher asked students to upload presentations in the closed group. Students started commenting each other's work on their initiative, later teacher gave to the process more academic and organized face. She taught how to give positive feedback to peers. Teacher noticed that students got more motivated while expecting their peers assessing their work and kept on with the process.

5 Conclusion

This study has sought to understand how the schools manage the change in digitally enhanced learning ecosystem. We used grounded theory to analyze the interview data collected from the earlier phase of the study and further investigate the cases from digitally enhanced schools group. The data revealed three categories to explain our phenomena in the study: Building school identity around ICT, emerging changes and driving issues and drawbacks. Innovative schools in our study tend to use ICT as a tool to build the transformative educational niche for the school. They impose the core digital activity through which technology is diffused. Technology takes more administrative than educational implication from school administration. Technology-enhanced learning is more bottom-up initiative of the innovative teachers. The change in classroom settings is exposed in the change of teacher and students' roles, educational activities and collaboration patterns.

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Digital Workers' Preferences Towards the Informal Learning Ecosystem for Distributed Workplaces

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Abstract. Supporting informal workplace learning in distributed work settings with socio-technical systems is an emerging paradigm in technology-enhanced learning. Based on the recent EU research projects IntelLEO and Learning Layers, this paper addresses some key challenges of cross-settings workplace learning and outlines some technological functionalities as opportunities to overcome these challenges. The key problem addressed in this paper was identifying which learning opportunities provided by such systems the workers would approve, and how the different opportunities of socio-technical systems might support the learners as a learning ecosystem. The survey was conducted with workplace learners from the domains of Educational Technology, IT-Management and Human-Computer Interaction to estimate their preferences to socio-technical system functionalities for learning in distributed workplaces. Based on the survey, a Bayesian dependency model of the socio-technical system functionalities was modelled which positions scaffolding interactions as mediators of self-directed sensemaking and co-creation.

Keywords: Socio-technical system · Informal workplace learning · Distributed workplaces

1 Introduction

Dynamic networked organizations need to transform in order to make use of learning at work for organizational change. More and more workers in physical as well as in digital settings work from different locations. Being alone in specific situated contexts, they often must tackle unfamiliar challenges. On the one hand, workers need urgent support in selecting suitable approaches and practices, and on the other, in considering organizational norms. These best practices may be available and circulating among the members of the distributed organization, but often there is lack of awareness of such practices and the information on whether these have been validated and approved at the organizational level is missing. Additionally, learning is not always effective when merely the examples of practices are provided. The support from domain experts might be needed, and the issue is finding relevant guidance and getting engaged with experts in personal or collaborative knowledge building. Furthermore, because of the urgency problems that they need to solve, people rarely have time to record their learning needs and moments and review their recordings in quieter moments. This hinders discovering

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knowledge gaps or innovative practices emerging in the organization. Another similar problem is adapting approved organizational knowledge in local contexts, which may suggest accommodations in the generally approved norms and may in the long term require revising the norms of the organization.

Digital technologies combined into socio-technical systems have recently started to provide opportunities for systematically tackling the abovementioned workplace learning issues.

The key problem addressed in this paper was identifying which learning opportunities provided by socio-technical systems for distributed work settings digital workers would approve, and how the different opportunities of socio-technical systems might support them as learners throughout the learning ecosystem. Chapter 2 provides overview of the challenges and digital opportunities using the research findings from European projects IntelLEO and Learning Layers. Chapter 3 introduces the methodology used for developing the survey, data collection and analysis procedures. Chapter 4 provides answers to the two research questions – "How do digital workers approve the socio-technical system functionalities for learning at distributed settings?" and "What is the learning ecosystem model that learners approve based on the survey results?" Chapter 5 discusses the findings from the socio-technical ecosystem principles point of view for informal workplace learning.

2 Informal Learning at Work in Distributed Work Settings

Informal work-based learning is spontaneous, work-related, just-in-time, and location-based learning at work that occurs on a day-to-day basis at work when professionals acquire new knowledge and skills or develop new approaches for solving problems [4, 23]. Workplace learning is a key strategy to meet the work challenges from the workers and organizations' perspective [8, 13]. Postindustrial jobs require being self-directed [9], confronting unstructured and new problems, engaging in independent decision making [3, 18], being creative [19], acquiring new information, learning new tasks [6], and learning from as well as teaching others [2]. The organizations need to build on individual workers' learning to dynamically update organizational knowledge, discovering and formalizing new knowledge, practices, guidelines and rules, and circulating those successfully among the workers to adapt to the turbulent economic and societal changes in the world [12, 15].

2.1 Challenges and Digital Solutions of Informal Learning at Distributed Settings

In this sub-chapter, some of the main challenges of informal learning at work are described from workers' and organizations' perspective. These challenges have been summarized based on the results of two recent EU projects that focused on cross-organizational learning. The EU 6th Framework project Intelligent Learning Extended Organisations (IntelLEO) (2008–2011) explored synergies of supportive technologies for learning and knowledge building activities in the community that emerges as a temporal integration of two or more different business and educational communities and organizational cultures (industrial, research and educational). The EU 7th Framework project Learning Layers (2011–2016) explored scaling up informal workplace learning in professional networks, across SMEs and in managed clusters.

Zhang and associates [24] report that during work-based learning, professionals mainly meet four kinds of difficulties: locating problems precisely, finding appropriate learning content for located problems, finding appropriate learning partners, and contacting those who are accessible. This is somewhat narrow view that undermines systemic organizational knowledge conversion. In the IntelLEO and Learning Layers projects we mapped empirically various barriers to learning and knowledge building: interpersonal barriers, intrapersonal barriers, individual-organizational barriers and cross-organizational barriers that hinder systemic management of learning and knowledge-building at work.

Many modern organizations are distributed between different locations, the workers in these locations have to tackle problems in their local context and have few opportunities to learn from each other's experiences. There are particular challenges in cascading new knowledge and experiences about good work practices or problems among professionals and across organization(s) [12]. For example, the workers do not know how to find or are not eager to find people with certain expertise to share knowledge and work together in a professional community; there is a lack of habit to collaborate to achieve shared goals with networking partners and partners from different communities; workers fear to demonstrate their lack of competences to their colleagues and superiors; there is little awareness of colleagues' expertise and their willingness to scaffold peers' advancement; the networking culture and habit of building personal networks to share knowledge and work together across organizational borders is missing; workers perceive difficulties developing shared community identity across organizational borders. In organizational learning, it is found challenging to promptly distribute and apply emerging organizational norms and practices in work context to appropriate them on individual level [12].

As people often work under time pressure, learning becomes secondary compared with the actual tasks in hand. Therefore, many of the learning moments individuals face at workplace remain untraced, and individuals do not return to what they have experienced. Workers often have no willingness and ability to plan appropriate paths of competence development and no habit of consciously directing their professional development. The habit of consumerism is prevailing among workers: they expect the provision of learning resources from top to down and are not actively searching for available new knowledge in their organization; they do not document novel practices or their own learning paths that could be used by themselves and other workers for learning. The challenge in workplaces is to achieve a situation where individuals would capture their learning needs, meaningfully connect learning episodes and reflect about them in situated contexts [9, 10, 12] and share the learning results with the peers in the organization and beyond. This would allow not only learning for individuals, but also would contribute to organizational knowledge.

The big challenge of informal learning is its low scalability beyond the immediate context and its fragmented, unsystematic provision at workplaces [12]. The authors suggest that scaling up informal learning at work with technology would require managing learning and support simultaneously from the individual, organizational and cross-workplaces networked perspective. Empirical findings in distributed workplaces [21] in IntelLEO and [12] in Learning Layers project identified several systemically interrelated workplace learning practices in distributed workplace networks that require technology support: *Sensemaking practices* are identifying learning needs, capturing learning needs and moments and revisiting these later on; organizing learning records, annotating these for later use and sharing with peers in organization. *Scaffolding practices* consist of seeking and offering help for learning (searching learning resources or experts, sharing help requests among networks, getting awareness on learning resources by recommendation mechanisms, guiding the peers). *Maturation Practices* are co-creating, socio-technical system-supported accumulating and validating of people and resources to develop organizational resources, norms and practices; and awareness mechanisms among workers.

2.2 Emerging Socio-Technical System Functionalities to Support Learning at Work in Distributed Settings

Several technologies have been used in socio-technical systems to support learning at work in distributed settings. Mobile devices allow professionals to personalize their learning environment, to be continually in contact with experts, look at digital manuals or books, find sources or interact with others online without the limitation of place and time, and benefit from adaptive and personalized learning support [24]. Commonly, systems for organizational learning support distributing learning materials and facilitating communication among learners and tutors while fewer learning management systems have the capacity to provide just-in-time, personalized, contextualized and work-related learning support in real working situations or adaptive personalized learning [24]. By codifying some of the strategies and rules that human tutors have been shown to use [1] adaptive learning technologies provide support for self-regulated workplace learners in solving tasks with the aid of more knowledgeable other(s) [7, 16]. Social networking and community technologies such as in professional forums [17] promote learning to solve problems with the help of networked peers. Portfolio communities provide support for self-directed learning in networked settings [22]. Knowledge maturing and semantic technologies have been used to improve shared knowledge and awareness of it [5, 20, 21].

Few socio-technical systems (e.g. the prototypical technologies developed in recent EU projects IntelLEO http://intelleo.eu and Learning Layers http://results.learning-layers.eu) provide systemically the functionalities to support the whole set of workplace learning interactions described above to achieve responsiveness of organizations.

IntelLEO project developed a set of semantic tools that supported organizational learning according to the phases of the extended Nonaka & Takeuchi's [15] knowledge conversion model: the Learning Path Creator [21], the Organizational Policy tool, the Knowledge Discovery tool, the Human Resource Discovery tool, Traceability/Monitoring tool with synergetic semantic support provided according to the integrated ontology framework. These applications combine functionalities for Sensemaking, Scaffolding and Knowledge Maturing.

The Learning Path Creator:

- Discovery and recommendation of learning resources while creating learning paths (Scaffolding & Sensemaking)
- Discovery and recommendation of other learners' learning paths while creating learning paths (Scaffolding & Sensemaking)
- Discovery and recommendation organizationally approved and highlighted learning paths while creating learning paths (Scaffolding & Sensemaking)
- Social awareness of other learners' learning process while creating learning paths (Scaffolding & Sensemaking)
- Discovery of learning partners while creating learning paths (Scaffolding & Sensemaking)
- Annotating learning paths with cross-organizationally shared ontology (Sensemaking & Knowledge Maturing)

The Organizational Policy tool:

- Creating organizational incentives for learning paths, roles, tasks (Knowledge Maturing & Scaffolding)
- The cross-organizational competence development and mapping to evolve competence ontologies (Knowledge Maturing & Sensemaking & Scaffolding)

The Knowledge Discovery and Human resource discovery tools:

- Annotating knowledge resources, human resources and working groups with cross-organizationally shared ontology (Sensemaking & Knowledge Maturing)
- Discovery and recommendation of learning partners from knowledge discovery tool and human resource discovery tool (Scaffolding and Knowledge Maturing)

Learning Layers project developed mobile and web-based applications for workplace learners (AchSo!, Bits and Pieces, Learning Toolbox, Confer, Social-Semantic Services Dashboard, Living Documents, Confer) that were integrated with the service-based Social Semantic framework tailored to informal learning applications and combined functionalities for Sensemaking, Scaffolding and Knowledge Maturing:

In-context help-seeking and experiencing:

AchSo!

- Learning and re-organizing, searching, finding, annotating, sharing, co-constructing knowledge resources and workplace learning experiences in situ (in video format) (Sensemaking, Scaffolding, Knowledge Maturing)

Learning Toolbox

- Learning and re-organizing, finding, sharing, annotating and co-constructing knowledge resources and workplace learning experiences in situ (as documents, photos, videos etc.) (Sensemaking, Scaffolding, Knowledge Maturing)

Enhanced collaboration and knowledge building:
Living Documents

– Recommending, co-constructing, sharing, annotating and accumulating knowledge resources (professional documents, guidelines) (Sensemaking, Scaffolding, Knowledge Maturing)

Confer

– Co-constructing, sharing, annotating and accumulating shared knowledge resources (structured discussions) and getting expert guidance (Sensemaking, Scaffolding, Knowledge Maturing)

Bits and Pieces

– Recommending, learning and re-organizing, annotating, sharing, accumulating and co-constructing resources and experiences made at workplace (Sensemaking, Scaffolding, Knowledge-Maturing)

SoAR

– Requesting help, getting expert guidance at workplace (Scaffolding)

Extended trust building/improved use and creation of learning resources:
Social Semantic Server (SSS)

– Recommending experts, knowledge resources and annotations based on user's activities and contextual factors; accumulating knowledge (Knowledge Maturing)

SSS Dashboard

– Finding experts, validating by technology means, accumulating knowledge (Scaffolding, Knowledge Maturing)

IntelLEO and Learning Layers tools and services have never been fully applied in real workplace settings to enable the users to benefit from synergies of Sensemaking, Scaffolding and Knowledge Maturing interactions in one setting and for a longer period of time. In our study, we aimed at investigating the digital workers' preferences as to the full set of possible functionalities – the Workplace Learning Ecosystem – which may support informal workplace learning in distributed workplaces.

3 Methodology

The survey was developed based on the informal learning interactions in workplaces described by Ley and associates [14]. The survey items elaborated possible socio-technical system functionalities using the ideas from the prototypes of Learning Layers tools. The online survey was comprised of three groups of statements that represent the socio-technical learning system dimensions for informal learning at work:

I. Sensemaking statements: Learn & organize knowledge (11), Share knowledge (5), Annotate knowledge (5)

II. Scaffolding statements: Search resource (3), Find resource (2), Awareness of resources (5), Find expert (4), Share help requests (2), Get expert guidance (6)
III. Knowledge maturing statements: Accumulate knowledge in system (5), Co-construct knowledge (7), Validate resources and experts with technology means (5)

The full survey is available online [25]. The data were collected from the workplace learners in Human-Computer Interaction, Educational Technology and IT-Management professions attending master studies (18 men and 26 women). The age of respondents ranged from 22–54 years, with average age 32 years. 44 surveys were filled in. The data were analyzed with SPSS statistical means (compound mean values, K-means analysis for clustering, Cross-tabulation and Linear modelling), and the Naïve Bayesian modelling using the dependency modelling tools (http://b-course.hiit.fi/obc/) developed by Myllymäki and associates [14].

4 Results

4.1 The Workplace Learners' Preferences to Use Specific Types of Socio-Technical System Functionalities for Learning at Work

K-means analysis discovered 2 groups of users (Group 1- Pessimistic values (N = 19), Group 2 - Optimistic values (N = 25)) that differed statistically significantly ($p < 0.001$) in the mean compound values of all the Sensemaking, Scaffolding and Knowledge maturing statements (Fig. 1).

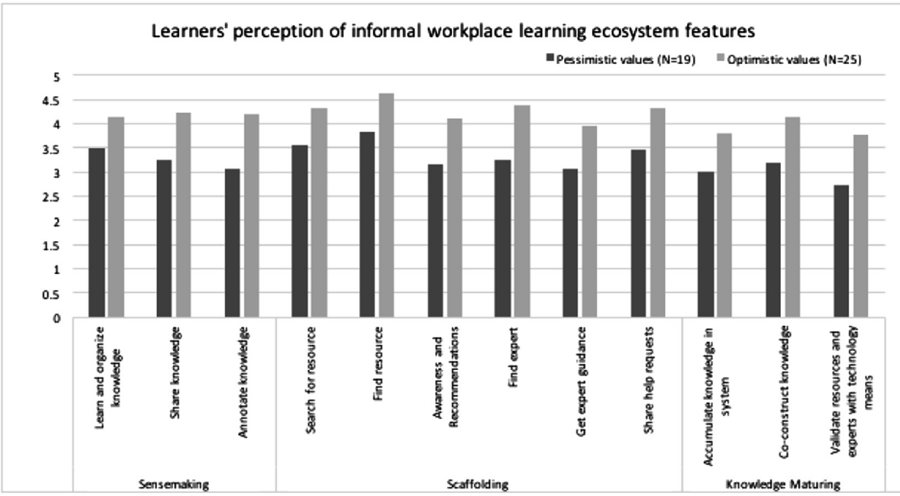

Fig. 1. Overview diagram of learners' perception of informal workplace learning ecosystem features (mean values of compounds in two significantly different user clusters)

These user-preference groups were not gender-related but there was an age-related dependency ($p < 0.05$): older digital workers had more pessimistic values than younger ones. We also found that some statement groups related with social interactions such as *Getting expert guidance* (mean = 3.55) or requiring socio-technical interactions such as *Accumulate knowledge in system* (mean = 3.45) and *Validate resources and experts with technology means* (mean = 3.32) were rated in average lower than the rest of the statements. The lower rating of *Getting expert guidance* may be explained by the workers' pragmatic expectation that the support would never fade out, although this expectation violates one of the scaffolding principles (to decrease support when learner's expertise increases to increase learner's self-direction). Lower ratings of socio-technical functions such as *Validate resources and experts with technology means* and *Accumulate knowledge in system* could be explained by dislike towards collective and automatized (out of personal control) recognition of people and accumulation of content.

4.2 The Model of the Socio-Technical Ecosystem Functionalities for Informal Learning at Work

Zhang and associates [24] propose the following sequence of guidance acquisition during work-based learning activities: *Locating the problem in work context*; *Finding appropriate knowledge and skills* or *Finding appropriate learning partners*; *Asking from learning partners for solution or discussing with them*, where some *Learning partners take the expert role providing the solution or being the discussion partners*; *Learning from the resources acquired*; *Reviewing acquired knowledge and skills* or *Progressing in extending the knowledge and skills*.

Our socio-technical informal workplace learning ecosystem model contains some of the Scaffolding and Sensemaking components described by Zhang and associates [24], but in addition, it has the components of Knowledge-maturing and Sensemaking that relate to semantic technologies (*Annotating knowledge, Awareness of knowledge, Share knowledge, Accumulate knowledge in system, Validate resources and experts with technology means*). Secondly, our model has a collaborative knowledge construction dimension (*Co-construct knowledge*) that reaches beyond the discursive scaffolding acts between the learner and his learning partners. Thirdly, differently from [24], our *Learning and re-organizing knowledge* interactions particularly highlight the aspects of self-directed learning (*Discovering learning needs, Making records of ones' learning, Revisiting learning records, Reflecting on learning records, Organizing learning records*).

We have built a naïve Bayesian model using the dependency modelling tools (http://b-course.hiit.fi/obc/) developed by [14]. The final model (Fig. 2) was found from 34070604 candidate models. Reading the model is the following: if the removal of some model statements makes the model much less probable, it can be considered as an important arc (dependency). If removing the arc does not affect the probability of the model much, it can be considered to be a weak dependency.

Removing any of the lilac arcs from the model would decrease the probability of the model less than one millionth of that of the original model:

Learn and reorganize -> Get expert guidance
Co-construct -> Get expert guidance
Search -> Get expert guidance
Get expert guidance -> Accumulate

Removing any of the dark blue arcs from the model would decrease the probability of the model less than one thousandth of the probability of the original model (exact ratio listed):

Share help requests -> Find expert (1:246391)
Learn & reorganize -> Share help requests (1:123536)
Co-construct -> Validate with technology means (1:35345)
Co-Construct -> Share (1:11487)
Find expert -> Awareness (1:3642)
Share help requests -> Co-construct (1:2844)

Finally, removing any of the light blue arcs below decreases the probability of the model (exact ratio listed):

Find resource ->Share (1:889)
Find resource -> Learn & reorganize (1:519)
Search -> Share help requests (1:188)
Find expert -> Get expert guidance (1:149)
Learn & reorganize -> Share (1:258)
Learn & reorganize -> Annotate (1:183)

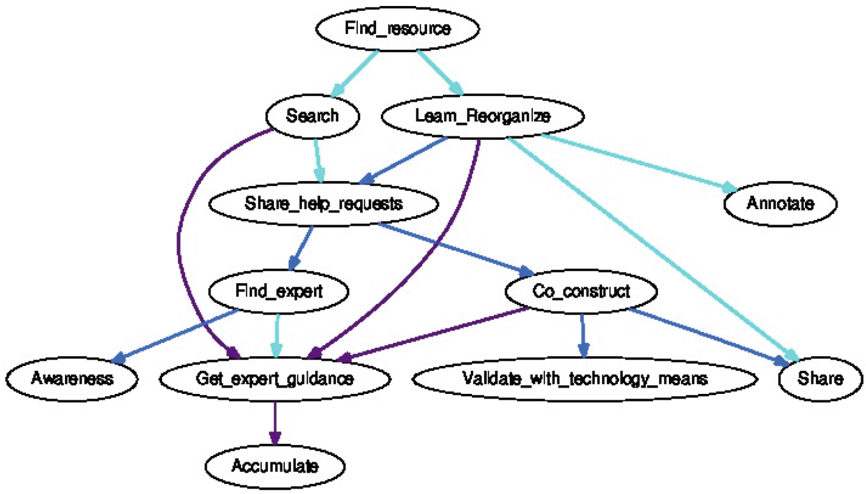

Fig. 2. A dependency model of the socio-technical system functionalities for informal workplace learning ecosystem (important dependencies are marked with lilac lines, medium ones with dark blue lines whereas the weak dependencies are marked with light blue lines, the arrows are used for the known direction of the dependencies between the model components) (Color figure online)

Final Bayesian dependency model for of the socio-technical system functionalities for informal workplace learning ecosystems positions centrally (with most arcs) the self-directed *Learning & reorganizing knowledge* (identifying learning needs, capturing and actively making learning records at work, organizing learning records, reflecting on records, organizing records) and *Co-creation of knowledge* (using collaborative efforts in knowledge construction such as integrating shared contributions and resources in collaboration, improving norms in networks of experts).

The ecosystem model for informal workplace learning in socio-technical system indicates that *Learning and reorganizing knowledge* in the context of self-directed learning at work gets input from *Finding resources (*weak dependency*)* and contributes to *Annotating* and *Sharing,* which in turn are the products of *Learning and reorganizing knowledge* in the socio-technical system. Both *Sharing* and *Annotating* are learners' interactions with socio-technical system's technology functionalities (e.g. sharing access rights, tagging) that contribute to the common knowledge pool in the workplace. Dependencies exist between *Learning and reorganizing* with *Getting expert guidance* (strong dependency) and *Learning and reorganizing* with *Sharing help requests* (moderate dependency). The interactions in the first self-directed level of the ecosystem model indicate the perceived higher importance of social peer-learning interactions compared with socio-technical interactions in the workplace learning ecosystems for informal self-directed learning.

Find resource has also weak dependency with *Searching for learning resources.*

Searching for learning resources relates to social interactions in the ecosystem, having strong dependency with *Getting expert guidance* and weak dependency with *Sharing help requests. Sharing help requests* in the socio-technical system's networks is important to support learning partners in *Finding the experts* (moderate dependency). *Sharing help requests* may lead to *Co-constructing knowledge* (moderate dependency). *Finding the experts* can provide access to learning support in form of *Getting expert guidance* (weak dependency) or increase the *Awareness of resources* (moderate dependency). *Getting expert guidance* contributes to *Accumulating* knowledge with technology means around the resources in socio-technical system, such as the use-histories of resources, learning episodes, personal notes, discussions or usage contexts organized around resources (strong dependency).

Co-constructing knowledge appears to have strong dependencies with *Getting expert guidance,* which is a social interaction level of the workplace learning ecosystem, and moderate dependencies with *Validating knowledge with technology means* and *Sharing knowledge,* which both require learners' interactions with socio-technical system's technology functionalities (e.g. endorsing, rating, access permissions).

5 Discussion

The dependency model visualizes the interactions between Sensemaking, Scaffolding and Knowledge maturing opportunities in a socio-technical ecosystem of informal workplace learning. Three starting points for interactions could be found from the model starting from *Learning and reorganizing Knowledge*, *Search for knowledge* results and *Co-construction*. The dependency model indicated the mediating role of social interactions in the system such as *Getting expert guidance* and *Sharing help requests* in connecting self-organized *Learning and reorganizing knowledge*, *Search for knowledge* and *Co-construction*. Two loops could be described in the informal workplace learning ecosystem:

I. *Sensemaking and reorganizing -> Scaffolding -> Knowledge Maturing*
II. *Co-constructing -> Scaffolding -> Knowledge Maturing*

In our previous studies in portfolio-based socio-technical system for workplace learning [22] we also found based on real interaction data that the experts in peer-to-peer workplace learning system had influenced directly their colleagues' co-construction of knowledge. Furthermore, they could indirectly influence other workers' individual sensemaking and reorganizing of knowledge.

Our model describes the socio-technical interactions (*Awareness, Validate with technology means, Annotate, Share, Accumulate*) rather as end-points of the dependencies without any input arcs to Learning, Guiding and Co-constructing. In systemically functioning socio-technical learning ecosystems such as the ones in forums, technically aided interactions for validating content and users' credibility and expertise (e.g. rating, (dis)liking, giving stars, accumulating usage histories, endorsing, thanking) are often hoped to generate a certain level of the technological scaffolding that might automatically recommend organizational knowledge in the learning process, as well as enhance the co-construction processes [17].

6 Conclusions

This paper explored the opportunities of socio-technical system as a learning ecosystem for informal learning at work. The results from a survey with digital workers about their preferences concerning different opportunities in socio-technical system enabled us to propose a model of informal workplace learning ecosystem that depicted the central role of different forms of human and socio-technically assembled scaffolding for self-directed sensemaking and collaborative co-creation at work. Testing learners' interaction within the real socio-technical ecosystem for informal workplace learning requires scaled-up learning activities in distributed settings which was beyond the scope of IntelLEO and Learning Layers research projects and the technology readiness of the developed prototypes. However, we hope that our survey findings are useful for designing and implementing informal workplace learning tools as systemic learning ecosystems.

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