eLmL 2014

The Sixth International Conference on Mobile, Hybrid, and On-line Learning

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eLmL 2014 Editors

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eLmL 2014

Foreword

The Sixth International Conference on Mobile, Hybrid, and On-line Learning (eLmL 2014), held between March 23-27, 2014 in Barcelona, Spain, continued to bring together federated views on mobile Learning, hybrid Learning, and on-line Learning. eLmL 2014 was dedicated to educators, eLearning experts, and students to exchange their ideas, experiences and lessons learnt in different facets of modern learning.

As the ease of execution increases, more and more institutions are discovering the benefits of delivering training via the Web. Interest in e-learning is at an all-time high. Such business trends as an increased global economy, the pressures for rapid development, and the necessity of teamwork are shaping the present state and the future of eLearning.

Employees are increasingly aware that they must continue to update and advance their skills if they want to understand the state-of-the-art technologies and remain valuable to their organizations. This means that learners will be more and more self-directed, and they will want access to what they need, when they need it. The Internet based educational materials and the e-learning providers have to meet this demand.

The conference focuses on the latest trends in e-learning and also on the latest IT technology alternatives that are poised to become mainstream strategies in the near future and will influence the e-learning environment. Ubiquitous systems proliferate quickly due to the latest achievements in the industry of telecommunications, electronics, wireless, and economical globalization.

Wireless and mobility allow any user to timely use resources using various access technologies under (assumed) secured and guaranteed privacy. The family of mobile devices expanded dramatically, allowing a user to have a portable office everywhere, every time. Mobile learning became a fact, due to the technical accessibility and Internet communications. Many online classes, learning systems, university curricula, remote education, and virtual training classes are now part of the corporate education and use.

Progress is made in user modeling and adaptive learning models. The generalization of successful practices on mobile learning is favored by many national and international projects and policy synchronization boards. Adaptation implies also the use of the classical methods, still in use and useful in some contexts and for some categories of users. Hybrid learning is an increasing trend in education today. The traditional classroom learning has been historically proven beneficial. Hybrid learning is rather a series of different learning strategies going from teacher-centric to student-centric. This improves the critical thinking, creativity, self-management, self-study, and advance problem solving thinking of the student.

We take here the opportunity to warmly thank all the members of the eLmL 2014 Technical Program Committee, as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to eLmL 2014. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the eLmL 2014 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that eLmL 2014 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the areas of mobile, hybrid and on-line learning.

We are convinced that the participants found the event useful and communications very open. We hope that Barcelona, Spain, provided a pleasant environment during the conference and everyone saved some time to enjoy the charm of the city.

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Table of Contents

An Existential-Humanistic Process Model of Knowledge Creation

Evidence, Limitations, and Potential for Innovation in Virtual Organizations

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***Abstract*—Despite rigorous business strategies, astute leadership, abundant capital, state-of-the-art technology and tools, creative skilled workforce, and established processes, many companies are waking up to a scene of despair. The tumultuous times of change marked by a complex business environment, exponential technologies, and market turmoil are driving the race to the finish for innovation. The premise of this research study was that if people are ultimately responsible for leveraging organizational assets and their own intellectual and imaginative resources for the creation of knowledge, then their need for a sense of community should matter and guide the social structure of their omni-connected work environment. From the participation of 264 knowledge workers across more than 12 industries, this quantitative study found that 48% of knowledge creation can be attributed to sense of community characterized by feelings of co-leadership, connection, belonging, give and take, ability to influence organizational outcomes, and creative growth. The results revealed that both high-tech and high-touch work practices, such as telecommuting, spontaneous face-to-face interactions, and synchronous and asynchronous collaboration lend positive support for sense of community, the source of undeniable advantage. The strategic outcome of this study is an existential-humanistic process model of knowledge creation presented along with evidence, limitations, and potential for innovation in virtual organizations.**

Keywords-knowledge creation; innovation; sense of community; technology-mediated collaboration; virtual organization; telecommuting; needs fulfillment; emotional connection; group membership; influence; socialization; externalization; combination; internalization.

I. INTRODUCTION

A business environment characterized by shocks, disorder, and volatility can drive unadaptive companies to extinction, while persistently favoring, to the bitter end, companies that are prepared to innovate. Knowledge creation has therefore long been recognized in the business literature as a crucial construct [1][2]. Scholars and practitioners from a range of disciplines have devoted their energies to uncovering ways to foster the creation of knowledge [3][4][5]. The reality is that knowledge creation, rather than being about the talent of a single individual, is an interpersonal process [6][7][8]. Knowledge is created out of a rigorous dialectical exercise of gathering, interpreting, communicating, synthesizing, and applying collective reasoning, observations, and experiences [9][10][11].

Dialectic collaboration is a means for amalgamating human ideas permeated in a multiplicity of social, cultural, and historical contexts [12]. Exponential technologies have opened doors for evermore participants to join in virtual collaboration [13] to solve the foremost challenges facing their organizations. Being more impersonal and inhibited than face-to-face interactions, virtual collaboration can lead to conflicts and misunderstandings [5] and increase the risk of perpetuated acrimony and stress [14]. This dilemma surrounding virtual work has spawned off a vociferous debate among practitioners and scholars. Meanwhile, companies across the board are struggling to find ways that not only promote social bonds, workplace fluidity, and serendipitous encounters, but also foster employee flexibility, engagement, and loyalty [4][5]. Yahoo! and Hewlett Packard, two of the companies caught in the virtual work dilemma, have reversed their longstanding telework practices [15][16][17], without comprehending how that makes them vulnerable to a subtractive effect detrimental to innovation [12].

Knowledge is a complex, organic asset [18][19] that arises out of an interdependent process of collective imagination [4][8]. Literature is replete with evidence that throwing money perfunctorily into research and development or incentive systems does little to promote innovation capabilities. Apple ranked the most innovative company for three consecutive years, yet its spending on research and development was nearly half as much as that of its nearest rivals [20][21]. The fact that the companies judged the most innovative and the best places to work for are vastly different [21][22] suggests that innovation is neither a result of inundating research and development with resources nor is it about pampering employees with over-the-top perks.

The most powerful strategy for companies seeking to build and sustain the capacity for innovation is to focus on the virtues, skills, and knowledge of people and how to connect their talents [23][5]. For companies aspiring to produce game-changing breakthroughs for their markets, the game change must begin at home. We argue that sense of community, the imperceptible link that connects and drives people, is both an antecedent and a consequence of knowledge creation and, as such, that the overarching priority of organizations must be to shape the social structures of knowledge work with a careful consideration to sense of community.

The next section comprehends the important theoretical research and empirical studies published in the literature on

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knowledge creation, sense of community, and social structure of virtual organizations. The sections on problem and purpose statements interpret the problem researched and state the purpose of the study. The following sections present the research questions used to extend prior theory, the instruments underpinning the study, and the research framework of this study. The sections that follow present the results and limitations of this study. Finally, the conclusions and the scope for future work are presented.

II. LITERATURE REVIEW

Enduring companies are built by people having the passion to bring innovative products to life [4][24]. To such companies, success is more than material gains. Knowledge, the root of innovation, is fueled by humanity. When the participants feel a sense of belonging, know that they make a difference, and believe that their commitment will get them what they need, they are said to share a sense of community [25][26], which helps build trust, inspire sacrifice, and power collaboration [27]. The social connection renders the knowledge creation process organic by helping grow the participants' personalities and extend the response repertoire of the company sustainably over time. While the human ability to find patterns in random noise and apply imagination is crucial [4][24], knowledge creation is not about the talent of a single individual with bounded rationality [10][28][29][30].

Dyer et al. [9] observed that innovators are consistent exemplars of the skills for questioning, observation, networking, experimentation, and association. Knowledge creation includes generation, improvement, application, and utilization of new ideas [31, p.70], the basis of which is in the social, cultural, and historical contexts of the individual [32]. However, interpersonal networks are indispensable to a dynamic evaluation, permeation, and adoption of knowledge [5][33], characterized as complex, tacit, subjective, embedded, and socially constructed [6][34][35].

Sense of community is an invisible force that unites people, embodying trust and affection associated with feelings of sacrifice, loyalty, and engagement [36]. It affords an aggregation of human assets needed to deal with forces in the external and internal environments [37], and delimits in-groups from out-groups and creates a form of safety, belonging, and intimacy among the participants [25]. Interpersonal configurations flourish if the relationships that underpin them are accumulative [38]. Hirshi [39] held that attachment, commitment, involvement, and belief in common values were the principal aspects of social bond, a facet of the sense of community. A measure of bonding is social capital, which Putnam [23] referred to as the currency of trust, partnership, compassion, and communal interplay that not only satisfies the social needs of an individual, but also bears the potentiality for the improvement of the collective unit to which the individual belongs. Nisbet and Perrin [40] observed, "First and foremost of the social bond is the symbolic nature of all true behavior or interaction" (p. 39). Sense of community stimulates extension of the interpersonal selves of participants in the knowledge creation process, resulting in a broadening of the response repertoire of the organization [12][28].

An ever-increasing number of companies are adopting a distributed, networked structure, in which collaboration among dispersed people is largely mediated by technology. Such workplaces are called virtual organizations, wherein the knowledge workers are considered the most valuable asset [1]. Companies across the board are in a battle for talent. Drucker [1] observed that managers must treat knowledge workers as volunteers who are more concerned about autonomy and empowerment, connection with their peers, and engagement in organizational governance than they are about pay. Virtual organizations work when they offer workers a share in collective success, a way to govern themselves, effective collaborative structures and processes, and technologies for communication and coordination [13]. The downsides of virtual organizations, however, include virtual communication being more inhibited than face-to-face interactions and conflicts and misunderstandings being more pronounced [5]. Since social interplay is essential to knowledge creation, the need to understand how proper work practices and social dynamics might help overcome the shortcomings facing virtual organizations is greater than ever before.

Social technologies, including video telephony, have altered the concept of virtual organization. Pervasively available synchronous and asynchronous collaboration tools afford geographically-distant employees with the feeling of being together by enabling them to track position, opinions, movement, actions, and voice [41][42][43]. However, the fundamental prerequisite to knowledge creation is a free and fresh flow of ideas across organizational levels in physical and virtual work environments [44], for only when the participants' subjective and objective discernments afforded the opportunity to fuse is knowledge utilized and proliferated [8]. Hamel [2] suggested that being prisoners to the paradigms established and supported by the bureaucratic class may have limited further innovation. Changing these paradigms is counter to the traditional way of thinking and being [45]. McMillan and Chavis [26] observed that "the first task of the community is to make it safe to tell 'the Truth'" (p. 316). Adverse group and intergroup relationships are the sources of anti-learning behaviors and organizational defenses detrimental to knowledge creation [18], a sense of community fostered by healthy interrelationships is the foundation of knowledge making in human-centered organizations [2][7][46].

Knowledge creation at the foundation of innovation has, in fact, been acknowledged as a dynamic process of continuously resolving contradictions, chaos, and conflicts [12], which can often be sources of stress rather than job satisfaction [14]. Employees noted for leading Apple's transformation to the world's most innovative company described their journey as both *inspiring* and *unsettling* [4].

Just as human muscles get stronger when subjected to physical strain [11], knowledge creating organizations benefit from pressure, disorder, and unpredictability, provided their energies are suitably invested in talent, process, and tools [21]. In a global environment where innovation is front and center on the agenda of companies [9], it is crucial to understand how to sustainably foster knowledge creation.

III. PROBLEM STATEMENT

Exponential technologies have placed organizations in a dilemma by lifting the barriers to borderless collaboration [5][41], while rendering social interrelationships more impersonal and inhibited [2][13]. Evermore people are able to collaborate with great flexibility, yet their interplay is prone to conflict, misunderstanding, and distress [14]. Collaboration remains situated in legacy work practices and a leadership mindset that favors hierarchy, silos, and rigidity over practices that free people to stay human, express their creativity, and empower them to design their own work spaces [47]. Sense of community, the tacit link that allows people to build bridges across departments and geographic boundaries, can aid in resolving this dilemma by helping companies balance inclusion, cohesion, and empowerment. Knowledge creation and sense of community have long and independently been investigated [6][9][12][25], but the linkages between the two constructs have not been adequately explored in the ubiquitous context of omni-connected virtual organizations. Innovation is a field of unfair advantage and the lifeblood of business success [48]. There is therefore an urgent need to develop an understanding of the relationship between sense of community and knowledge creation and construct an instrumental model of knowledge-based work practices for the optimization of sense of community.

IV. PURPOSE OF THE STUDY

The purpose of this quantitative research was to investigate the relational linkages between sense of community and knowledge creation in the ubiquitous context of virtual organizations and explore the social structure of knowledge work with regard to sense of community. Knowledge-creating ability can only be sustained when organizations drive out self-protective, coercive, and socially-closed behaviors and instead offer workers a share in communal success, ways to express and govern themselves, and effective collaborative structures, tools, and processes.

V. RESEARCH QUESTIONS

The following three research questions guided this study:

1. What is the nature of relationship between sense of community and knowledge creation?
2. What is the nature of relationship between sense of community and structure of knowledge work?
3. What are the most important variables in the above relationships?

VI. RESEARCH FRAMEWORK

Sense of community has been described as "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" [26, p. 9]. The four factors that encompass the force of sense of community are group membership, influence, needs fulfillment, and emotional connection. Group membership is a perception of oneness that leads members to act along the salient characteristics of the group. Influence is a mutual sense of significance and making a positive impact. It is a bidirectional concept that applies to the group member as well as the group. The needs of group members may include status, success, and association. A strong community arranges members and provides them with opportunities to satisfy their mutual needs. Emotional connection arises from the history the members share or recognize with. The more the positive experiences the members have experienced together, the greater their bond. In summary, a strong sense of community is built from members sharing a sense of oneness; feeling a bidirectional influence; having their needs of status, success, and association addressed; and experiencing a growth of social bonds with other members.

In Nonaka and Takeuchi's [8] constructionist model, new knowledge forms a spiral resulting from four modes of interactions between implicit and explicit forms of current knowledge, namely socialization, externalization, combination, and internalization. Socialization is the process of transferring implicit knowledge through a sharing of day-to-day experiences. Externalization is the process of making implicit knowledge explicit through articulation and communication. Combination is the process of synthesizing the implicit and explicit forms of current knowledge into an explicit form of new knowledge. Internalization is the process of assimilating or making implicit the explicit knowledge gained through the combination process. The process of incorporating knowledge into the regular activities of the organization has also been termed routinizing [5]. In summary, knowledge creation is a continuous and dynamic process of making current knowledge accessible and, through a dialectical process, enabling interactions among individuals in the organization and external environment drive the construction of new knowledge.

Sense of community is the locus (source) and work practices are the mechanism (means) in the knowledge creation (outcome) process. The technologies for communication and coordination in virtual organizations include email, audio and video interactions, and asynchronous tools, such as wikis, blogs, and e-learning forums. Collaborative technologies have enabled telecommuting, whereby employees are able to work

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remotely. The consideration of the demographics of the participants, namely the diversity of age (generations), gender, role, tenure, and national culture is also important to the comprehension of sense of community and knowledge creation.

Fig. 1 illustrates the broad conceptual framework of this research. Based on the above discussion of knowledge creation, sense of community, and work structure, the following fundamental linkages were hypothesized:

H1. Sense of community is positively related to knowledge creation.

H2. Work practices are positively related to sense of community.

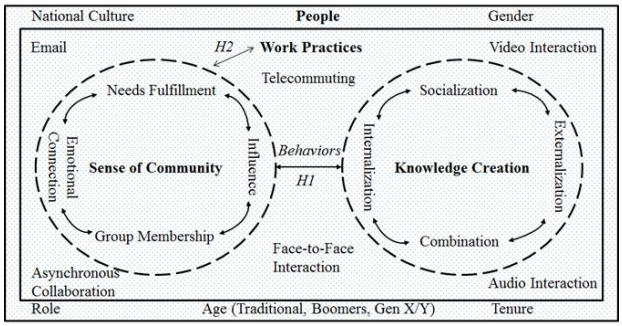

Figure 1. Locus (Sense of Community) and Mechanism (Work Practices) of the Outcome (Knowledge Creation).

VII. INSTRUMENTS

The 8-item Brief Sense of Community Scale (BSCS) [49] represented the sense of community dimensions of needs fulfillment, group membership, influence, and emotional connection. The BSCS was used with certain adaptations to be consistent the format of the combined survey and the research context. The 10-item Knowledge Creation Practices (KCP) [50] assessed the construct of knowledge creation based on Socialization, Externalization, Combination, and Internalization (SECI) processes of the knowledge creation theory. The KCP scale was used with certain significant adaptations not only to be consistent with the format of the combined survey and research context, but also to add further clarity to questions. The authors demonstrated their respective scales to possess acceptable levels of psychometric robustness.

VIII. RESULTS

Data for this research were obtained through a combined survey composed of adapted versions of the BSCS and KCP survey instruments supplemented by five demographic items and eight items related to work practices. The survey was hosted on Constant Contact, an online marketing company. The combined instrument, including the 13 new items and modifications to the original BSCS and KCP scales, was re-tested for reliability and factor goodness. The final instrument was confirmed to be psychometrically sound. Results of the reliability and factor analyses are available upon request.

From a professional contact database comprising 15,979 knowledge workers, such as skilled and qualified engineers, scientists, and managers, a random sample of 2,354 names was drawn, representing a wide range of industries and demographics. Emails were sent to the selected participants informing them of the purpose of the research and soliciting their voluntary and confidential participation. Of the 2,354 invitees, a total of 286 knowledge workers participated. 22 entries had to be discarded due to incomplete entries. A tally of 264 participants made this study, representing an 11.21% return rate. Data were analyzed using both SPSS v.13 and Minitab 16.

45 (17.2%) of the research participants were from the education industry, 44 (16.8%) were from healthcare, 34 (12.9%) from technology and telecommunications, 31 (11.7%) from service, 23 (8.6%) from government, 10 (3.9%) from consumer products, 9 (3.5%) from energy, 8 (3.1%) from banking, 7 (2.7%) from manufacturing, 7 (2.7%) from consulting, 5 (1.9%) from biotechnology, 4 (1.6%) from entertainment and leisure, and the remaining 35 (13.4%) were from the defense; software; food, beverage, and tobacco; transportation; aircraft; automotive; cargo handling; chemical; real estate; and sports industries.

More than twice as many females participated in the study as males. Participants whose work location was the United States dominated the study in terms of raw count. All age groups were represented in the study, except for workers under the age of 21. The participants spanned the entire range of tenure in their organizations. The largest representation was of those with more than 15 years of experience. Similarly, all the roles in the organization were represented, with senior managers having the largest representation.

Shapiro-Wilk and K-S tests of normality indicated that the constructs of sense of community and knowledge creation as well as their subfactors have bivariate normal distributions, making it possible to run parametric analysis. Data supported both hypotheses, *H1* and *H2*. We concluded that 0.48 (or 48%) of the variation in knowledge creation could be explained by the linear relationship between sense of community and knowledge creation. This means that about 52% of the variation in knowledge creation can be explained by factors other than sense of community. Such other factors may include the skills and creativity of the participants, leadership effectiveness, processes and tools, organizational culture, R&D and capital investments, and so on. The p value of .00 indicates there is sufficient evidence to support the claim of a linear relationship between sense of community and knowledge creation. Fig. 2 presents the linkages across work practices, sense of community, and knowledge creation, representing the first of the three parts of the existential-humanistic process model of knowledge creation.

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Although the factor of group membership was found to be independently related to socialization (r=.50, p=.00), externalization (r=.42, p=.00), combination (r=.49, p=.00), and internalization (r=.50, p=.00), it was found not to be significant when the influence of all the sense of community factors was considered collectively. It was noteworthy that audio teleconferencing and video teleconferencing were not significant to sense of community. This may be attributable to their limited deployment and usage in the participating organizations. Face-to-face interaction was found unrelated to sense of community both on its own and when considered with other work practice factors.

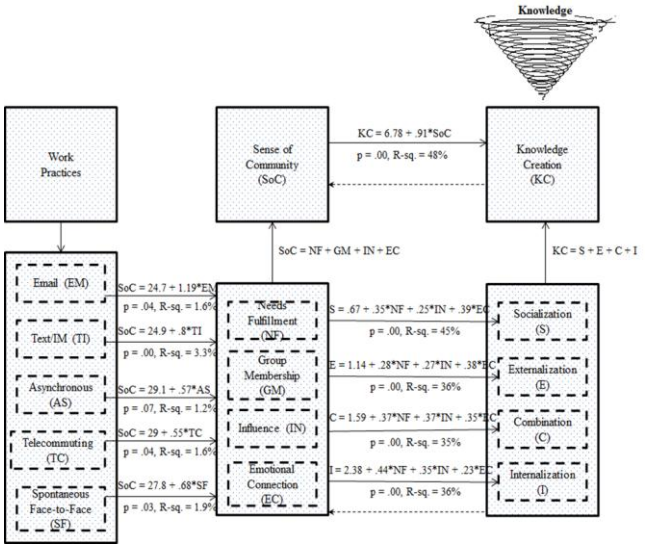

Figure 2. Part I: The Existential-Humanistic Process Model of Knowledge Creation

The results of ANOVA and general linear modeling indicated the significance of work practices on sense of community. The extent of telecommuting was found to be related to sense of community, needs fulfillment, emotional connection, and influence. The extent of ad interaction, defined as those interactions using instant/text messaging and spontaneous face-to-face meetings, was found to be related to sense of community, group membership, influence, and emotional connection. The extent of synchronous interaction, defined as those interactions taking place face-to-face, over instant/text messaging and audio/video conferencing, was found to be related to sense of community, emotional connection, group membership, and influence. The extent of asynchronous interaction, defined as those interactions taking place over email, wikis, blogs, and e-learning forums, was found to be related to sense of community, group membership, and influence.

A significant difference in the needs fulfillment score was found across the genders, with females reporting a higher mean score. The scores for sense of community, emotional connection, influence, and group membership were found to be significantly different across age and role. A significant difference in the needs fulfillment score was also found across age. No significant difference was found to exist in any of the sense of community dimensions across tenure. Participants aged 60 and above reported the highest scores for needs fulfillment, group membership, influence, emotional connection, and sense of community, whereas those between the ages of 21 and 30 reported the lowest scores. Senior managers reported the highest scores for group membership, influence, emotional connection, and sense of community, whereas individual contributors reported the lowest scores.

Fig. 3 illustrates the second part of the existential-humanistic process model of knowledge creation. Virtual collaboration is defined as the interface that occurs over email, text and instant messages, and asynchronous means, whereas proximate collaboration is defined as the interface that occurs over a face-to-face contact and over audio and video teleconferencing.

All four types of collaboration namely, virtual, proximate, synchronous, and asynchronous were found to be positively related to sense of community. The relationship of sense of community was found to be stronger with virtual collaboration than with proximate collaboration. Similarly, the relationship of sense of community was found to be stronger with synchronous collaboration than with asynchronous collaboration. To summarize, the five key findings of this study were as follows:

1. Sense of community is positively related to knowledge creation. 48% of the variation in knowledge creation can be explained by its linear relationship with sense of community.
2. Needs fulfillment, influence, and emotional connection are positively related to the four stages of knowledge creation, namely socialization, externalization, combination, and internalization.
3. Work practices are positively related to sense of community. Email, text and instant messaging, asynchronous interaction, telecommuting, and spontaneous face-to-face interactions are supportive of sense of community.
4. Virtual collaboration is more positively related to sense of community than proximate collaboration. Synchronous collaboration is more positively related to sense of community than asynchronous collaboration. Despite their positive relationship with sense of community, telecommuting and spontaneous face-to-face interactions are in sparse use across virtual organizations.
5. The more senior the member in both age and role terms, the higher his or her score for sense of community.

IX. LIMITATIONS

The cross-sectional nature of this study yielded only a snapshot of the understanding of sense of community, knowledge creation, and work practices. The sample for this study was not representative of the workforce. For

instance, twice as many females participated in this study than males. As such, the results could not be generalized.

A limitation to the reliability stemmed from the low Cronbach's alpha for the factor of influence, suggesting a small degree of inconsistency in the meaning drawn by the participants for the factor. The influence of microeconomic and macroeconomic conditions, the honesty of the participants in their responses, and the culture and maturity of the participating companies was uncontrolled. No definitive cause-and-effect relationships could be drawn.

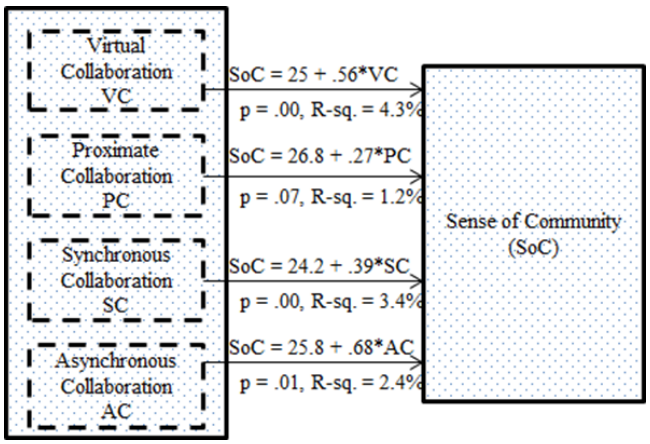

Figure 3. Part II: The Existential-Humanistic Process Model of Knowledge Creation

X. CONCLUSION AND FUTURE WORK

This quantitative study integrated the two constructs significant to knowledge-driven organizations, namely sense of community and knowledge creation and investigated their interrelationships through an examination of talent, technology, and work practices. From the participation of 264 knowledge workers across more than 12 industries, this quantitative study found that 48% of knowledge creation is attributed to sense of community, which is characterized by feelings of connection, belonging, give and take, ability to influence organizational outcomes, and creative support in omni-connected organizations. The results revealed that both high-tech and high-touch work practices, such as telecommuting, spontaneous face-to-face interactions, and synchronous and asynchronous collaboration lend support for sense of community, the source of undeniable advantage. The strategic outcome of this study was an existential-humanistic process model of knowledge creation presented along with evidence, limitations, and potential for innovation in virtual organizations.

While this study investigated the linkages between the constructs of sense of community and knowledge creation, follow-on research may focus on associated factors that may work together to sway the constructs. This study evaluated the constructs of sense of community and knowledge creation without considering the influence of other contributing factors, such as business strategies, leadership, capital and R&D spending, state of technology and tools, creativity and skills of the workforce, and processes in use. Subsequent research may replicate this research study with longitudinal approaches and triangulation methods to test the consistency of findings. Such studies might explore the lived experiences of the participants and the performance of their organizations over time.

This study serves as a reflection of technological adoption at a given point in time. Follow up studies might track shifts in the use of technology. As previously mentioned, it cannot be said that geographic and national culture differences do not contribute to relational outcomes. The opportunity to repeat this study across national cultures is also present in order to grow a multicultural understanding of knowledge and people practices.

This study did not attempt to examine the physical environment within which knowledge work is accomplished. Future research may explore the blend of work practices, such as telecommuting, ad hoc interactions, and synchronous and asynchronous collaboration in order to optimize sense of community and knowledge creation. Research may be supplemented with more in-depth evaluation of the specific work practices within companies, prevailing extent of sense of community, and innovation outcomes. In particular, research is warranted in understanding the influence of sense of community among the learners in online universities and its long-term consequences on the overall development and success of their graduates.

The participants in this study indicated a limited use of video technology, making it difficult to glean the influence of video-based collaborative technologies on sense of community. It might be worth replicating this study in companies where video technologies are more broadly deployed.

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Using an Expert System to Automatically Map the Learning Profile of Individuals

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***Abstract*—This paper presents a new integrated, web-based system for assessing the learning aptitudes, the learning styles, and the potential of the brain hemispheres of individuals. Specially designed psychometric questionnaires are adopted and a new battery of tests – that is, a combination of factors – is proposed. The analysis of the factors is carried out by the Ariston expert system shell, and statistical data is presented regarding the reliability–validity of the system.**

Keywords–learning styles; aptitudes; personality; psychometric testing; expert systems

I. INTRODUCTION

The higher education environment presents several challenges for students who are frequently faced with the task of taking decisions that affect directly their academic progress, and ultimately their career prospects. For successful academic decisions, a student must consider carefully several different matters, investigate all possible alternatives (e.g., the electives), think analytically, and above all, apply logic of the form "What-if…". The environment itself poses several demands regarding learning, while frequently the students are disappointed because it becomes rather difficult for them to understand the reasons they cannot master certain concepts, and generally why they fail.

One of the most demanding tasks is that of acquiring new knowledge while mastering new concepts and solving problems. This process raises several issues related to the duration of learning, the degree to which the student can actually master new concepts, and of course the degree to which the student is content and happy with the progress made [1].

In order to study alternative modes of learning, we frequently theorise on the way people a) understand things, b) acquire experience, and c) realise the world around them [2]. In all cases, we have to distinguish between "Learning that…", which is related to knowledge itself, and "Learning how…", which is related to knowledge through practical experience, or platforms and modes of learning. In both cases, learning is influenced by well-defined categories of factors, including the following:

a) The degree to which the personality of the person – measured on the Holland scale [3] – matches with the academic course–subjects being studied, and ultimately the career planned. The personality is analysed under six types: Realistic, Investigative, Artistic, Social, Enterprising, Convention. The scores of these types are compared and matched with the requirements (scores) of professions from a large database.
b) The learning styles of the person (e.g., auditory, visual, kinaesthetic, etc.) [4].
c) The way the teacher / professor treats the individual, and generally the way the course material is presented to the learner [5].
d) The background knowledge of the learner, given that a person can learn practically, independently of academic environments.

The research results and findings we see in the literature [4][5][6] cover partially and in isolation aspects of the problem of learning, discussing individual factors without offering an integrated approach that will help a student discover the actual causes of problems with learning and then take remedy action. Also, most of the tests and questionnaires available are based on the so called "norms", whereby the measurements of a person are compared with those from a selected sample, underestimating the person's standards and potential. In other words, we claim that the use of only the norm scores is not adequate, and can sometimes do injustice to those learners with special talents and personality traits that are on the borderlines of the norms. Besides, there isn't any tool available for use by the students themselves who need to know: a) the reasons of their poor academic performance, and b) ways and modes of studying that can improve their rate of learning.

This paper addresses this issue, and proposes a web-based system that adopts a complete set of psychometric factors that measure: a) the learning aptitudes and difficulties, b) the learning styles, and c) the potential of learning of the brain hemispheres of an individual. Besides, the web-based system [7] provides a universal centralised database that enables the dynamic assessment of all students–newcomers being tested. Evidently, a desk-top application cannot provide universal, dynamic norms. The learning profile is created without any human intervention, offering in effect a "map" with detailed measurements

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regarding learning factors. Although we refer to "Students", our research results are equally applicable to everyone, regardless of whether they are students or working adults.

The academic–school environment is often the setting where the learning disabilities of a person first become apparent. We usually notice problems in one or more of the following basic areas: Mathematics, Language, Cognitive development, Short- and Long-term Memory, Attention, Concentration, Organization, and Fine Motor Skills, where a difficulty is otherwise known as dyspraxia or kinaesthetic. Generally speaking, a person with learning difficulties faces problems in a) identifying, b) collecting, c) organizing, d) manipulating, and e) acting on verbal or non-verbal information. These problem areas are directly related to the learning aptitudes of an individual and must therefore be translated to their equivalent psychometric factors, as we explain later.

Evidently [1][2], a person learns and gains knowledge or skill through action, study, schooling, experience, education, training, and generally, by processing data and information selected by their basic senses (sight, smell, taste, touch, and hearing). A learning difficulty, regardless of its cause or nature, does not indicate subnormal intelligence, but rather a learning environment that is not suitable for the person under investigation. This means that individuals must be compensated for, with special tutoring and a learning environment that is in congruence with their personality traits. Our aim here is to discover how a person learns best, that is, the modes under which the person gains maximum knowledge or skill. The modes we adopted following extensive investigations on their reliability are: a) Auditory, utilising the sound, b) Visual, utilising vision, c) Linguistic, utilising the written word, d) Kinaesthetic, utilising movement, touching, e) Interpersonal, utilising interpersonal relationships, and f) Intrapersonal, showing a preference to study alone and to think independently.

Finally, we cannot ignore the physiology of the human brain with its two hemispheres, each one specialising in specific functions and services, utilising its own sensors and information processors. It appears that each hemisphere prefers to deal with certain activities and cerebral functions, performing the best it can. We adopted well-formed items that measure the "laterality", that is, the degree to which a hemisphere is developed in relation to the other – in other words, the potential of each hemisphere. This enables us to gain insight on whether a person learns best using top-down or bottom-up techniques [5][6].

Through specially designed and normalised psychometric questionnaires, we have managed to diagnose inherent and acquired traits of learning, with the ultimate objective to help the learner adopt effective modes and means of learning, that is, to learn how to learn. At the same time, the findings help the teacher adopt the best approaches to impart new knowledge.

For practical applications, experimentation and measurement of the reliability–validity of our approach, we used the Ariston shell [8], which is an expert system for multifactorial analysis of psychometric data. The knowledge contained in the expert database is classified by age, sex, nationality, academic departments, occupations and specializations, aptitudes, abilities, and several other psychometric data regarding thousands of young people and working adults. We selected and tested 7 factors with 49 items for learning aptitudes–difficulties, 6 factors with 76 items for learning styles, 2 factors with 21 items for both brain hemispheres, and 4 factors with special algorithms that measure the degree of sincerity in the answers of the person being tested, computing an overall truth score. One of the reasons these 4 factors are not included in the report is that they are not really useful to the teacher. They are used by the expert system to measure the various levels of sincerely in the answers and take appropriate action (e.g., to recommend re-sit of the test).

This paper presents research work carried out during the last two years. Section II begins with the assessment of learning aptitudes–difficulties, Section III continues with learning styles, and Section IV analyses the potential of brain hemispheres. Section V presents an overview of a real-example profile, and Section VI concludes with evaluation results regarding the reliability–validity of our battery, and directions for future research.

II. LEARNING APTITUDES–DIFFICULTIES

Our approach adopts state-of-the-art theory for testing cognitive abilities using spatial and diagrammatic reasoning, beyond the Cattell-Horn-Carroll theory of cognitive abilities [9] and the Wechsler scales [10], which evolve around the traditional approach that includes language and mathematical knowledge. Our approach utilises those realms of thought where the person appears to have learning difficulties and problems in assimilating new information beyond previous experience and reasoning [11]. By assessing the ability to quickly understand and assimilate new information, we can predict how responsive to education and training the person will be.

Well-established approaches to item design were adopted in order to assess specific areas of learning. The questionnaires consist of items that require the recognition of patterns and similarities between shapes and figures, the inference of rules from given sequences (e.g., diagrams, symbols, etc.), the application of rules to new situations, and reasoning from given data and information. Figure 1 presents a typical question where the learner is expected to select the shape from the second row that is assembled from the partial images of the first row.

The Factors Tested and Adopted

The factors we have tested and adopted were first introduced by Yannakoudakis [11], and are independent of attainment. They can also be used to provide an indication of intellectual potential.

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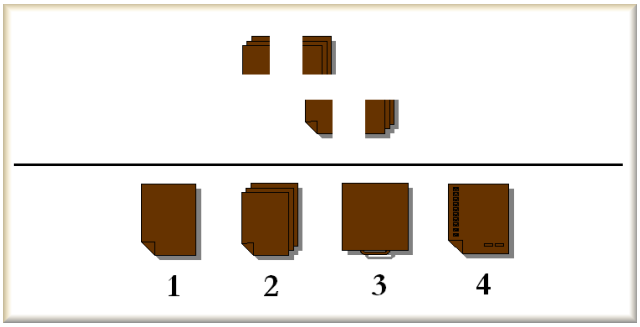

Figure 1. Learning aptitudes: Example item.

1) Matching concepts: This factor assesses aptitude to match elements, look for common attributes amongst given sets, and identify similarities. A high score implies that the person is in a position to spot identical elements, avoid "re-invention of the wheel", match similar concepts, and recall successfully from memory as and when necessary.

2) Composing concepts: This factor investigates aptitude to analyse incorrectly-ordered or isolated elements of knowledge, put these in the correct order, identify common attributes, and synthesise supersets of concepts or objects. A high score implies that the person is in a position to examine elements of knowledge (individually, as well as in union), evaluate these, and synthesise new hyper-sets of elements or objects.

3) Understanding intersection: This factor assesses aptitude to compare sets of elements and identify those elements that form the intersection between them (i.e., the elements that are common among the given sets). A high score implies that the person is in a position to detect overlap amongst concepts, isolate common elements, count elements with common attributes, and ignore non-homogeneous elements.

4) Reconstructing concepts: This factor assesses aptitude to analyse incomplete data and information, in order to reconstruct objects and concepts. A high score implies that the person is in a position to utilise partial knowledge and come to logical conclusions, integrate knowledge, fill gaps, reconstruct mutilated objects or concepts, and guess correctly.

5) Understanding rules: This factor assesses aptitude to detect the rules and regulations that govern the formation of logical sequences that bind objects or concepts together. A high score implies that the person is in a position to analyse the data given and identify logical structures and "if…then…else…" constructs, forecast the next step successfully, apply the rules to new situations, and come to logical conclusions using a stochastic approach to reasoning.

6) Understanding subsets: This factor assesses aptitude to compare sets of elements given, and identify subsets. A high score implies that the person is in a position to compare sets on the basis of their cardinality and features, count homogeneous elements, identify narrow terms, separate narrow terms from broad terms, and generally understand well the concept of "*A* is included in *B*".

7) Identifying analogies: This factor assesses aptitude to analyse a given state of objects or concepts, and determine whether there is an analogy between them. A high score implies that the person is in a position to identify and process analogies, explain how we can go from one concept to another, process functions, and generally compare and contrast elements of the information available.

An overall high score indicates that the learner has the ability to grasp new ideas and assimilate new information, has responsiveness to training, and a high level of natural ability. A low score indicates that the learner has difficulty in grasping new ideas, and needs more time to solve problems consisting of unfamiliar concepts, new procedures or tasks.

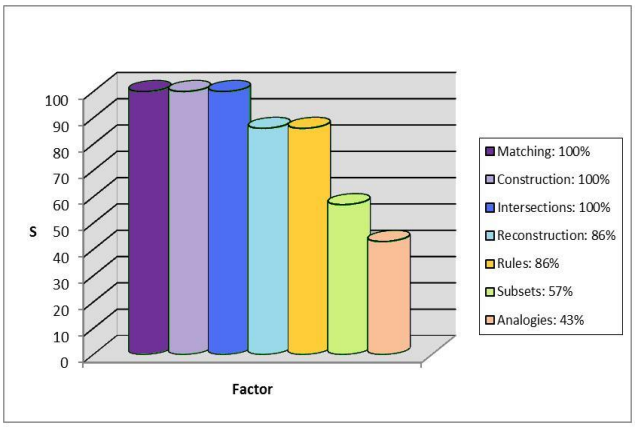

Figure 2. A real example with learning aptitudes, where "S" represents the score, and "Factor" the factor tested.

Figure 2 presents a real example. Here, we can see the results of an individual that experiences serious problems with analogies and subsets. The teacher can then take action to help the person improve low-score factors by giving appropriate exercises and realistic examples that cover each domain of knowledge.

III. LEARNING STYLES

The aim here is to investigate the distribution of well-established learning styles, that is, modes under which the person gains knowledge or skill. Each mode is related to a corresponding type of emotional intelligence [4], which affects directly the rate of learning of a person. Note that some learning styles remain stable throughout the life of a person (Auditory, Visual, Linguistic), while others can change with time (Kinaesthetic, Interpersonal, Intrapersonal). In any case, the longer a person is left with a learning disability, the more difficult it becomes to train them to alternative methods of knowledge acquisition. Moreover, the longer a person remains under an unsuitable learning environment, the slower his rate of learning will be, even after special tutoring [2][4].

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The Factors Tested and Adopted

1) Auditory: This type assesses ability to learn by utilising auditory information, including lectures, speeches, tape recordings, etc. Auditory learners like singing, whistling, making rhythmic sounds by tapping their fingers or legs, playing musical instruments, and listening to music. They are also good at distinguishing sounds and rhythms in music, remembering melodies, and listening with their "inner ear". Their rate of learning increases when speaking rhythmically or turning speech into lyrics.

2) Visual: This type assesses ability to learn utilising visual information, including images, diagrams, drawings, transparencies, moving pictures, etc. Visual learners like modelling, drawing, painting, imagining, dreaming, making notes, and building things. They are good at imagining, finding their way, reading maps, and remembering things from images. They are motivated by visiting art galleries, museums, cinemas and theatres. Finally, they express themselves through drawings, paintings and constructions generally.

3) Linguistic: This type assesses ability to learn utilising linguistic data and information, including the written word, relationships between concepts, summarisation of texts, conclusions from texts, etc. Linguistic learners like talking, reading, writing, spelling, listening to and telling stories, playing word games, and having conversations. They are good at remembering names, places, dates and everyday things. They are motivated by visits to libraries, meeting writers, and the experience of words in theatre and music. Finally, they express themselves through discussions, interviews, and the written word generally.

4) Kinaesthetic: This type assesses ability to learn utilising kinaesthetic information, including touch, movement, personal experience, experimentation, etc. It also assesses ability for scientific exploration by various means and instruments. Kinaesthetic learners like moving, running, jumping, constructing, gesturing, dancing, and touching things. They are good at sports, dancing, acting, and making things with their hands. Finally, they express themselves through their body, action, repetition, and making things with their hands.

5) Interpersonal: This type assesses ability to learn through interpersonal relationships, socialisation, exchange of ideas, parties, etc. Interpersonal learners like testing themselves and their thoughts in relation to others, having many friends, and being part of a community. They are good at organising and playing a leading role, mediating between people, and playing the role of a referee. They are motivated by taking part in social meetings, parties, festivals, and artistic events. In general, they express themselves by participating in social groups.

6) Intrapersonal: This type assesses ability to learn in isolation, including studying alone, thinking and acting independently. Intrapersonal learners prefer to retrieve information from their own sources, having total control of the learning environment, selecting the books that suit them, concentrating on the subject they choose at a time, and so on. They like setting their own goals, dreaming, planning and relaxing. They are good at working alone at their own pace, they are persistent, and they follow their intuition. They need diaries and planning, keeping notes, but above all, they need privacy while studying. Finally, they express themselves through uniqueness and authenticity.

Figure 3 presents a real example of a learner who experiences problems when studying alone, and is also not keen to learn by reading books and notes. Instead, this particular person learns effectively by talking to others, having others commenting on their solutions, and so on. This person also learns best through kinaesthetic processes.

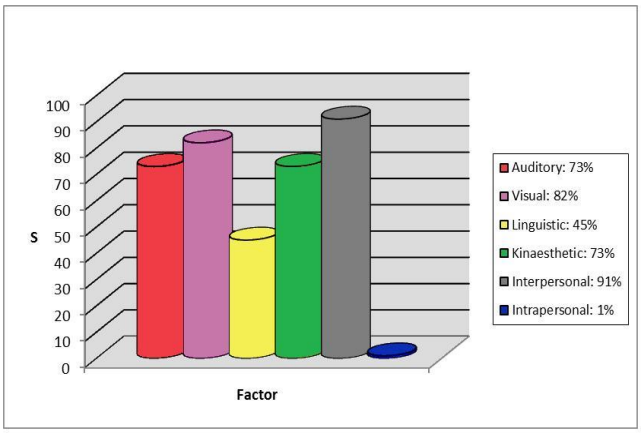

Figure 3. A real example with learning styles, where "S" represents the score, and "Factor" the factor tested.

An example question is presented below:

Which of the following would you readily choose?
1. To act as a referee for a match
2. To act as a score keeper for a match

IV. POTENTIAL OF BRAIN HEMISPHERES

The left hemisphere is specialised in the linear processing of data and information, and in the analysis of data, placing emphasis on the detection of the constituent parts rather than the whole. For example, an individual with a developed left hemisphere first notices the details in a picture and then the whole. Thus, the individual recognises the partial objects of a puzzle first, and then proceeds to the synthesis of the picture. The individual therefore learns more easily in a classroom where knowledge is communicated beginning from the detail and ending with the general. The left hemisphere controls the logical and the rational way of thinking, and has an aptitude for linguistics, academic research and science. Left-hemisphere learners are methodical, use rules and axioms, and tend to complete the project they are working on before they engage in something else [5][6].

The fields that the left hemisphere prefers are: Future, Logic, Syllogism, Methodology, Analysis, Research, Intellectuality, Language, Scientific Thought, Mathematics, and Conscious Thought.

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The right hemisphere is specialised in the simultaneous processing of data and information, in composing information, and prefers the whole, rather than the constituent parts. For example, individuals with a developed right hemisphere first analyse the image as a whole, and afterwards pay attention to the details. Thus, they delineate the whole image of a puzzle, and then they proceed to the synthesis of its constituent parts. Right hemisphere learners acquire knowledge more easily after they have been informed about the subject of a lecture or have read a summary. Therefore, they are prepared having formed the necessary educational framework, which in turn is enriched by the knowledge and the details that follow. These individuals are capable of beginning an activity before completing another one; they conduct two actions simultaneously, leaving some projects unfinished, and as a result, they are forced to make the same effort twice, consuming precious resources and energy. Moreover, they have an aptitude for analysing space, demonstrate a creative way of thinking, prefer artistic activities, have intuition, and like mysticism and rituals.

The fields that the right hemisphere prefers are: Past, Intuition, Unconscious Thought, Creativity, Synthesis, Analysis of Space, Instinctive Side, Imagination, Sensuality, Music, Arts, and Practical Intelligence.

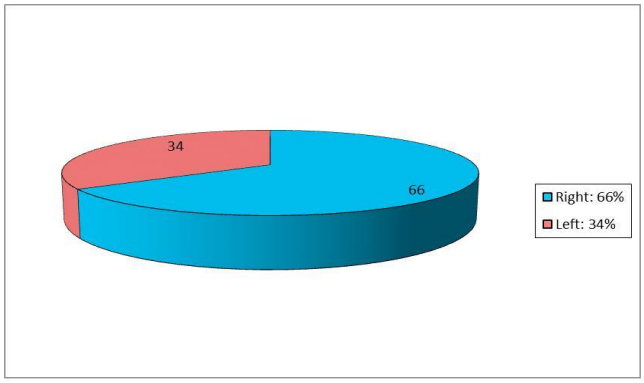

Figure 4. A real example with brain hemispheres.

Figure 4 presents the results of a real example, showing that this individual learns best when knowledge is presented in a top-down manner, that is, from the whole to the detail. An example question is presented below:

What would you readily select?
1. To do something with mathematics
2. Uncertain
3. To do something with language

V. OVERVIEW OF A PROFILE

For the reader to have an overview of a profile, we present some further statistics, all related to the same individual we have used in all the examples throughout this paper. We also explain the concept "probability of errors" in the answers given.

While answering the questions, the person may be distracted due to several reasons or events that cannot be predicted – noise, systematic error, psychological state, and so on – resulting to answers that do not necessarily represent his/her personality. The same can happen when the person answers randomly or inconsistently. In other words, direct or indirect distraction of individuals during the test can lead to incorrect classification of their learning factors. In this context, the probability of errors is considered to be a complementary measure to the truth scores.

In order to calculate the probability of errors, on the basis of the aforementioned, we make a hypothesis test and utilise the theory of stochastic processes [12]. Subsequently, we take the category of errors into consideration, in order to make corrections to the measures of the corresponding factors and, therefore, increase the validity and reliability of the conclusions reached by the expert system. The statistics that follow present a clear picture of the scores, while Table I shows the source and the equivalent Sten scores (scale 1–10), as well as the norms derived from our sample of over 500 cases, where N is interpreted as "Norrnal", L as "Low", H as "High", and VL as "Very Low".

Mean: 70.37
Variance: 796.51
Standard deviation: 28.22
Mean absolute deviation: 22.15
Coefficient of variation: 0.401
Overall truth score: 7 Sten
Probability of errors in answers: 0
Duration – Learning aptitudes: Shorter than usual
Duration – Learning styles: Normal
Duration – Hemispheres: Normal

TABLE I. SOURCE AND NORMALISED SCORES

Factor	Score	Sten	Norm
Right hemisphere	66	5	N
Left hemisphere	34	4	L
Interpersonal style	91	7	H
Visual style	82	6	H
Auditory style	73	6	N
Kinaesthetic style	73	6	N
Linguistic style	45	4	N
Intrapersonal style	1	2	VL
Matching concepts	100	7	N
Constructing concepts	100	7	H
Understanding intersections	100	7	H
Reconstructing concepts	86	6	N
Understanding rules	86	6	H
Understanding subsets	57	5	N
Understanding analogies	43	4	L

VI. RELIABILITY–VALIDITY AND CONCLUSIONS

The learning difficulties are often (but not always) highlighted when we detect disparities between the intelligence of a person (in whatever way you define this) and the academic–school performance. This does not mean

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that people with learning disabilities have low intelligence. In fact, they have average or above average intelligence, but their academic performance, as measured by standardised tests, is below what we would expect of people with the same age, intelligence, and academic grades (performance). Therefore, a person with low academic grades may be a person with learning disabilities (in terms of the factors presented here), rather than a person with low intelligence. Note that the battery of tests proposed here aims at analysing the inherent learning traits of a person, whereas the Wechsler scales [10] aim at analysing the intelligence of a person and the degree to which this affects learning.

Some difficulties will disappear with maturity, but some will not. The longer we allow wrong, or inefficient intellectual or physical tasks to continue (e.g., misspelling, incorrect use of a tool, handwriting grip, etc.), the harder they become to correct, because repetition of actions or reactions produces, if not always an inclination, at least an aptitude to act or react in the same manner and thus the habit. Also, if learning difficulties are left too long, some persons begin to display avoidance behaviour because they are not experiencing success.

In order to evaluate our battery, we studied the academic progress of 200 University students, and correlated their grades with the measurements from the battery presented here. The mean age of the participants was 18.9 years (SD = 4.1), of which 42% were males and 58% were females. We also administered equivalent tests from the Computer Academy Psychometric Series (CAPS) [7], in parallel with the battery presented here, and then carried out detailed statistical analyses, a subset of which is presented here due to space limitations.

TABLE II. RELIABILITY CORRELATION COEFFICIENTS

Factor	Parallel Test	*r*
Right hemisphere	Holland scale Artistic	0.72
Left hemisphere	Holland scale Investigative	0.73
Interpersonal style	Holland scale Social	0.91
Visual style	Diagrammatic	0.92
Auditory style	Music while studying	0.79
Kinaesthetic style	Holland scale Artistic	0.74
Linguistic style	Language (overall)	0.89
Intrapersonal style	Holland scale Realistic	0.79
Matching concepts	Language 1	0.88
Reconstructing concepts	Language 2	0.80
Constructing concepts	Language 3	0.79
Understanding intersections	Numerical 1	0.91
Understanding rules	Logic	0.85
Understanding subsets	Numerical 2	0.92
Understanding analogies	Analogies	0.87

Table II shows the factors of our battery, the equivalent tests used, and the Pearson product-moment correlation coefficient (*r*), which is very high in most factors, particularly with Interpersonal style, Visual style, Linguistic style, Matching concepts, Intersections, Subsets, and Analogies. Another interesting finding is that the correlation coefficient between the overall grade of students and the overall grade from the battery is 0.86, further supporting the reliability–validity of our approach.

Evidently, our approach can map the learning profile of individuals with a high degree of accuracy, since most coefficients are significantly higher than the minimum requirement of 0.7. We intend to continue the research by collecting and analysing profiles of students from different Universities, faculties and departments. Our next step will also aim at answering clearly the fundamental question: "*Now that I know my profile, what can I actually do to improve my rate of learning*?".

ACKNOWLEDGMENT

The authors would like to thank Professor Emmanuel J. Yannakoudakis (Athens University of Economics & Business, Department of Informatics) for his most valuable assistance, and for giving us full access to the expert system shell and his psychometrics database.

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Development and Assessment of CSCL System for Large Classrooms Using Collaborative Script

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Abstract— **In the area of Computer Supporter Collaborative Learning (CSCL) research, scripting collaborative learning is a relatively new but promising approach to promote learning. The term scripting is used to describe ways of prescribing relevant elements for collaborative interaction, such as group formation, roles, learning activities, sequence of learning activities. Many studies have shown that free collaboration without explicit scaffolding rarely produces effective interaction and that the script can be one of the most effective scaffoldings. Basing on reciprocal learning method, we have designed a script which allows students to create questions and answer them mutually. To implement this script for large classrooms, we have developed a CSCL system which has two important functions: automated group formation function that can form groups on the fly, based on students' personal traits, and chat function by which students can discuss each other within their groupe. For the evaluation, we have conducted an experiment with some 300 students in a large classroom to evaluate our system and analyze interactions in detail during each sequence of learning activities. Based on the assessment result, the learners felt encouraged to understand better about learning task. At the same time, it became clear that the quality of discussion on chat affects reciprocal question posing. As well, it was indicated that group size and knowledge level of leader or other members affect the process of reciprocal actions and activities at some degree.**

Keywords-Collaborative learning; CSCL;script.

I. INTRODUCTION

A. CSCL and its issues

According to the social constructionism presented by Vygotsky and the theory of legitimate peripheral participation presented by Lave and Wenger, the learning, which was understood as a cognitive process in an interior of an individual leaner, will be recognized as a social process, or social cognition that progresses while cooperating with others [1]. Far from denying the learning as an individual cognitive activity, the social cognition can promote knowledge construction at an individual level and metacognition for learning strategies, through problem-solving by discussing with others [2].

The environment for such collaborative learning is built on the computer network, and such computer technologies are used as a supporting tool to promote collaborative learning, which is called, Computer Supported Collaborative Learning (CSCL). Advantages of CSCL over the face-to-face learning are: learners who are geographically or timely distant from each other can learn, a large number of learners can learn and be managed, logs of the learning process in details can be saved for learners, managers and scholars to re-use them, learning software and contents can be used and many more.

On the other hand, many case studies on the collaborative learning point out that it is highly unlikely for leaners to carry out collaborative activities voluntarily while learning without an external scaffolding [3]. For this reason, in order to resolve such issues in learning, various methods have been developed to appropriately regulate and structure the learning process within a group for effective and productive work and discussions among learners.

In this study, one of such methods, "collaborative script" was implemented in the CSCL system and used in a large classroom in the university. First, the next section will provide the overview of the collaborative script.

B. Collaborative script and its issues

The concept of script was originally suggested by Schank and Abelson in the field of cognitive science, and it has a meaning of internalized knowledge about socially sharing steps and rules people should follow in a certain situation (e.g., eating at a restaurant) [4].

Once the concept was introduced in the field of collaborative study, the script became a series of external scaffolding methods that are provided to promote collaborative learning. The first study on collaborative script was proposed by O'Donell and Dansereau [5], which defines the script as a scenario for a small learning group, which prescribes in details, who is carrying out what kind of learning activities and when. Due to the complexity of the script before the learning activities themselves, learners needed to be trained to follow the script.

After the script was adopted in CSCL, instead of training learners to execute the script prior to learning, the system interface was used to indirectly lead them to the scripted learning process.

Many researches indicate that the script can be designed at 2 levels in the CSCL environment. First, there is a design approach at a macro level; it defines who will learn, what assignment subjects for a group and how to distribute tasks

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among learners. On the other hand, there is a micro level approach which consists in prescribing the details of each learning activity in order to revitalize social interactions among learners.

There have been many studies that indicate the effectiveness of various CSCL systems with the script, but there are some issues at the same time. First, there is an issue on controlling a compelling power of the script. In other words, it means how to deal with the risk of over-scripting which takes too much self-motivation out from learners [6]. Next, despite a lot of empirical case studies, yet there are very few suggestion on a script design model that can be commonly used, with some exceptions [7] [8]. About the first issue, we suggested previously a method to flexibly adjust compelling power of the script according to learners' traits and learning situation [9]. So, this study focuses on the second issue, adopting a design method as the approach in order to design the script based on the design principle and implement and assess it.

C. SWISH MODEL as Design Principle

The purpose of the collaborative script is to support the problem solving and knowledge construction by social interactions among learners. To do so, a mechanism to trigger effective interactions is an important element. A Swiss scholar, Dillenbourg, suggests SWISH model as such mechanism. This model is the design principle for collaborative script that gives tasks that would generate conflicts among learners; it is supposed to promote intense interactions (statements, explanations, discussion, etc..) to overcome these conflicts [10].

From this model, three script schemata are drawn as design guidelines : 1. jigsaw schema, 2. reciprocal schema, 3. conflict schema. This time, we adopt the reciprocal schema. The most well-known example is Palinscar and Brown's reciprocal teaching method [11]. In this schema, learners take turns assuming roles (summarizer, questioner, clarifier, predictor). So, Since the steps of the problem-solving process are distributed horizontally among learners, they must continuously collaborate to build a shared solution.

D. Structure of this paper

This paper is structured as follows. Section II presents the general outline and the purpose of this study, and Section III describes our CSCL system for large classrooms. The collaborative script design is discussed in Section IV. Then, we present our experiment and results from our evaluation in Sections V and VI. Section VII concludes the paper.

II. PURPOSE OF THE STUDY

In this study, the script based on the reciprocal schema, is designed and implemented in the system to assess its effects. The system is for an environment where several hundred students in higher educational institutions cannot interact with one another face-to-face. The collaborative learning is carried out by those students using the system online.

As for the assessment, assignments and chat log data are used to assess the quality of interactions during the collaborative process and its learning effects. By analyzing the correlativity between the two, we aim to have some guidelines for improving the script and design principle.

III. SYSTEM

As Fig. 1 shows, our system was developed for an environment, such as a large classroom with several hundred people at higher educational institutions where face-to-face group learning is difficult. A teacher and students gain access to the CSCL server through PCs that are connected to the network. Learners can form a group regardless of where their locations are, and a teacher can remotely keep track of learning state of each group.

A. System Overview

As Fig. 2 shows, the system consists of different functions, such as "automated group formation" and "questionnaire preparation" by which a teacher designs a collaborative learning, "assignment submission", "reciprocal reviews" and "chat within a group" that provide a collaborative environment to learners. "Learners' properties" in Fig. 2 are drawn from questionnaires and pre-tests that were administrated before. Based on the properties, the system automatically forms groups.

B. Flow of Collaborative Learning

The collaborative learning in this system are composed of 5 blocks, as Fig. 3 shows. The following is the learning flow.

1. "Prior Setting" allows a teacher to conduct questionnaires, prepare pre-tests and register to the system.
2. In "Pre-learning", each learner submits the questionnaire and pre-test which was registered in "Prior Setting" on the system.

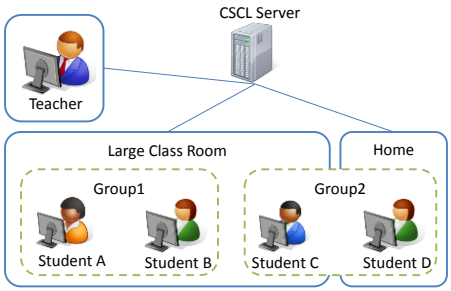

Figure 1. System overview

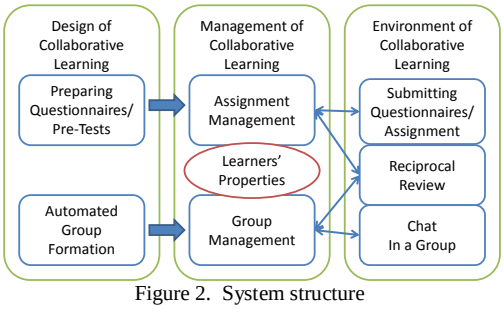

Figure 2. System structure

3. In ”Group Formation”, the system automatically forms groups based on the parameters the teacher has set and results of statements/answers by the learners. Small adjustments to the group formation can be made manually by the teacher.
4. In ”Collaborative Learning”, reciprocal reviews within a group and among groups as well as chat system within a group can be done in the system. The learners carry out these collaborative works according to the collaborative script.
5. In “Post Assessment”, the teacher reviews and grades submitted assignments.

C. Automated Group Formation Function

In this study, group formations are made possible in various ways that a teacher intends to do, by combining multiple elements of user characteristics that are obtained beforehand.

For example, a teacher can freely decide how many people to be in a group. He can also form flexibly groups with members of which properties are similar, or different.

D. Collaborative Script Function

In collaborative script, tasks are assigned according to roles, such as “Preparer”, “Answerer” and “Grader”. In the system, the group management function assigns tasks to each learner while the assignment management distributes allocated tasks. Also, roles which each learner is supposed to play and tasks are given automatically so that learners can work on their tasks at an appropriate speed without having to think about the collaborative script.

IV. COLLABORATIVE SCRIPT DESIGN

Supposing the experimental environment shown in Table1, the details of the collaborative script to be executed in the proposed system were designed.

A. Question-Posing Script

A script was made for the learning process in the task model called “reciprocal question-posing”. The following is a flow of ”reciprocal question-posing collaborative script”, which was designed in this experiment.

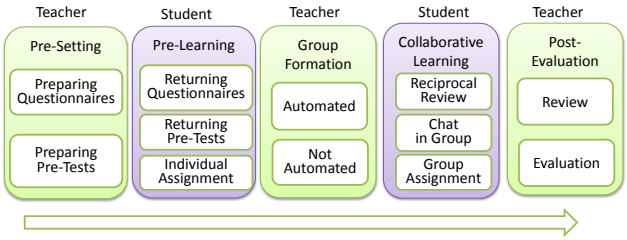

Figure 3. Flow of collaborative learning suggested by the system

TABLE 1. PRECONDITIONS OF COLLABORATIVE SCRIPT

Number of Students	Aboue 300 People
Member of Groups	3 People
Learning Time	90min × 2
Design Guideline	Reciprocal Teaching

Phase-1 : Preparing individual questions
A theme of question posing is given to learners. All the students prepare a question based on the given theme and submit it, including the answer and explanation about the question.

Phase-2 : Reviews within group
Regarding the question prepared at Phase-1, 3 members within a group are assigned as a question preparer, answerer and grader and review reciprocally within the group through the following activities (Fig. 4).
a. An answerer prepares answers to the questions prepared by a question preparer and submits the answer and evaluation of the question.
b. A grader grades the answer submitted by the answerer in a. and submits the graded result and evaluation of the question.
c. Based on the evaluation submitted in a. and b. a question preparer evaluates himself/herself,
d. The above process from a to c is repeated until all the learners rotate to take a different role within the group and become a question preparer

Phase-3: Question preparation within a group
Through a discussion in a group chat, a question must be prepared for submission. The answer and explanation are prepared along with the question.

Phase-4 : Submission and publish of final questions
Students submit a question/answer/explanation to their teacher. The teacher then publishes the questions as a assignment among groups.

Phase-5 : Solving questions reciprocally among groups
Students solve group questions that are published.

V. EXPERIMENT OVERVIEW

To assess this system, an experiment was carried out during a class at Tokyo University of Technology. The overview is as follows:

・Targets: Students at Tokyo University of Technology Freshman to Senior 298 students, 112 groups

・Dates for the experiment: January 10 (Tue) and January 18 (Wed), 2011

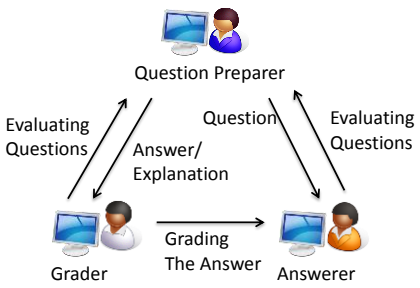

Figure 4. Group review

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・Lecture: Basics of the logic

・Learning assignment: students prepare a question; the question has statements in Japanese that represent an deductive inference that contain several premises and a conclusion. The answer must have a well–formed formula that represents correctly the inference, and a truth table that verifies the validity/invalidity of the inference. For this assignment, several exercises had been done during previous lectures. Also, similar question were distributed and completed as a pre-test one week before the experiment. The pre-test was graded by the teacher in charge.

The experiment was carried out during 2 days in a 90 minute class. On day 1, 60 minutes were spent for answering/evaluating reciprocally within each group. On day 2, another 60 minutes were spent for posing questions reciprocally within each group. The flows for learning are shown in Fig. 5.

The group review phase for day 1 is for answering/evaluating questions, grading/evaluating questions and self-evaluation. Fig. 6 shows evaluations of a question by a grader's point of view.

The group review phase for Day 2 is for preparing group question. Using a group chat function, learners discuss how to pose the final question.

In this experiment, a number of group members was set to 3, but there were some groups of less than 3 group members due to no attendance of some members. Specially, since groups could not be changed on Day 1 and Day 2, there were many groups of less than 3 group members due to no attendance of group members on Day 2. For this reason, the evaluation of this experiment was done on only 93 groups with group members of 2 or 3 on Day 2. Table 2 shows changes in a number of group members.

Also, on Day 1 carry out a group review, group members of less than 2 members could not carry out a group review. In this case, the groups of 2 members continued the learning using a different script that allows the 2 members solved questions and graded reciprocally. For a group of 1 member, the 1 member had additional members who came in late.

VI. ASSESSMENT

A. Automated Group Formation

In this experiment, groups were formed in a way that the academic level for each group is similar. Each group consists equal numbers of learners who ranked top, middle and low in the pre-tests about the content of the lecture. The results of the pre-tests were total points (perfect score is 400 points) of 4 pre-tests that had been implemented according to the progress of the lecture. All the grading was done by the same teacher. Fig. 7 shows the distribution of individual score and average score within group. Because the average scores gather in the median, the automated group formation functions normally.

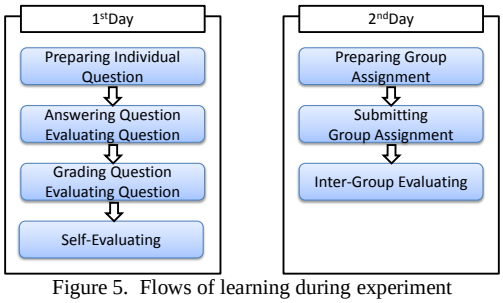
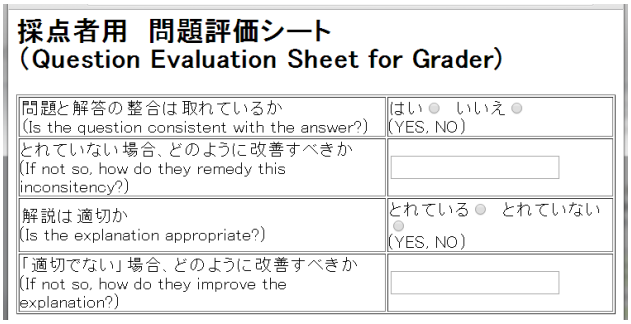


Figure 5. Flows of learning during experiment


採点者用　問題評価シート
(Question Evaluation Sheet for Grader)

問題と解答の整合は取れているか (Is the question consistent with the answer?)	はい ○ いいえ ○ (YES, NO)
とれていない場合、どのように改善すべきか (If not so, how do they remedy this inconsistency?)	
解説は適切か (Is the explanation appropriate?)	とれている ○ とれていない ○ (YES, NO)
「適切でない」場合、どのように改善すべきか (If not so, how do they improve the explanation?)	

Figure 6. Evaluations of a question by a grader's point of view

B. Question-Posing Script Evaluated by Learners

At the end of the experiment, we distributed a questionnaire to the students. Fig. 8 shows the responses to the question "Did you have a deeper understanding through posing questions?" Since many responded, "Deepened" and few answered, "Not deepened" and "Not at all deepened", the learners find the script effective.

Fig 9. shows the responses to the question, "what was the most useful reference while question-posing?". Responses as "Chat within Group", "Evaluation on questions by answerers" and "Evaluation on questions by a grader", of which teamwork take a large part, were highly evaluated.

C. Interaction within Groups

Contents of the chat were divided up into the following 5 categories: "Detailed discussion on important points", "Discussion on important points", "Discussion that often went off on a tangent", "Discussion that were mostly chit-chatting" and "Pointless discussion". The categories are shown in Table 3. We fixed these categories after the attentive reading of the contents of the chat. The evaluation was executed by 1 person according to the evaluation standard while the another checked the result.

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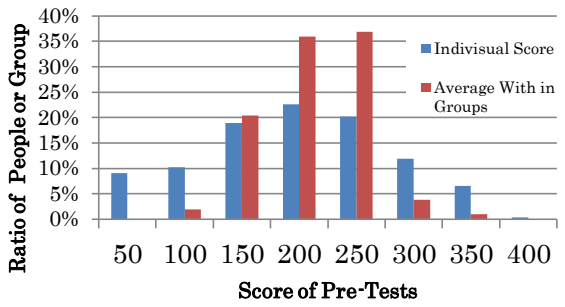

Figure 7. Distribution of individual score and average score within groups

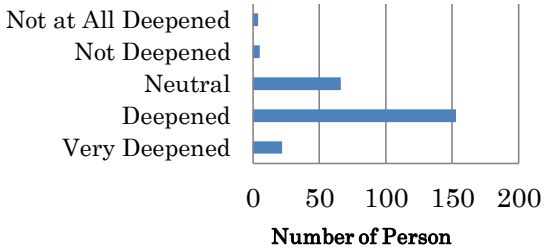

Figure 8. Responses to the question "Did you have a deeper understanding through posing questions?"

TABLE 2. CHANGES IN A NUMBER OF GROUP MEMBERS

Number of Members	Number of Groups	
	1st Day	2nd Day
3	77	40
2	32	53
1	3	15

TABLE 3. QUALITY OF DISCUSSION

Detailed Discussion on Importnant Points	Participants discuss carefully and meticulously to decide how to carry on.
Discussion on Important Points	Decision are taken by short discussions. Assignments are completed rapdely with modifications.
Often Went Off on a Tangent	Participants discuss on important points. But they chitchat often.
Mostly Chit-Chatting	Participants chitchat more often.
Pointless Discussion	Participants always chitchat and don't try to complete the assignments

Table 4 to 6 are extracted from the chat logs. Table 4 shows a part of discussions that was evaluated as "Detailed discussion on important points". It shows that 3 people consulted with one another on how to carry on.

Table 5 shows a part of discussions that was evaluated as "Discussion on important points". It shows that only some casual conversations were the basis for making a decision to carry on. Even after the conversations, there were many communications to inform what had been decided and agreements on what had been decided. "Going off on a tangent" contained chit-chatting in the above conversations while "More chit-chatting" had more chit-chatting than discussions.

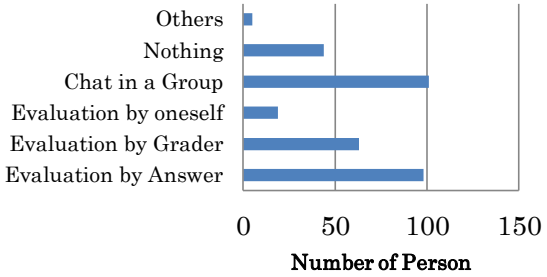

Figure 9. Responses to the question "What was the most useful reference while question-posing?"

TABLE 4. EXAMPLES OF "DETAILED DISCUSSION ON IMPORTANT POINTS"

Talker	Contents
D	Where do you want to change?
E	That's right … I guess, first of all, we definitely need to change the question, and then, what about the well-formed formula?
D	How is it that changes only the third line of the question?
D	Regarding the well-formed formula, it's the final part after ⊃.
E	That's good idea.
F	I agree. How do we want to change that?

TABLE 5. EXAPMPLE OF "DISCUSIION ON IMPORTANT POINTS"

Talker	Contents
G	Whose problem will we use?
H	How about I's Question? I don't have any particular reason for it though.
I	I think it's OK if it's corrected.
H	Then, let's make corrections on I's question and use itI.
G	All right, let's work it out.

TABLE 6. EXAMPLE OF "POINTLESS"

Talker	Contents
X	It's difficult to make a new question, isn't it?
Y	Why don't we pick the best question among three of us and submit it?
X	I think that's great!
Y	OK, let's do so.

Table 6 shows a part of discussions that was evaluated as "Pointless". It shows that the conversations were going into a direction of avoiding deep discussions.

Fig. 10 shows the quality of discussions by each group, of which chat logs were evaluated. In both groups of 2 or 3 people, more than 70% of all the groups fell into either one of the 2 categories, "Detailed discussion on important points" and "Detailed discussion", meaning that many groups had good interactions.

Fig. 11 shows the number of statements made per person within each group. In the groups of 2 people, an average number of statements made per person is 26.2 while in the groups of 3 people, the average was 22.3. These results suggest that in both groups, relatively active discussions were held, and the interactions were sufficiently activated. Also, a number of statements was higher in the groups of 2 people rather than in the groups of 3.

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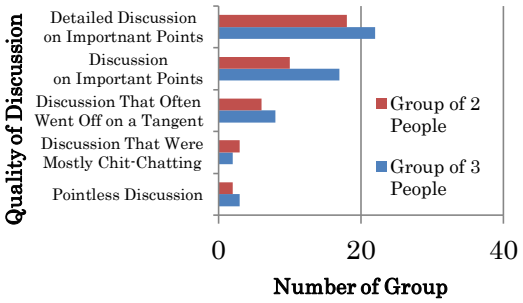

Figure 10. Quality of discussions and number of group

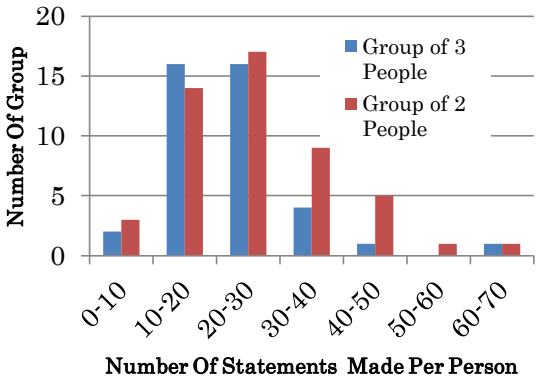

Figure 11. Number of statements made per person person within a group

Fig. 12 shows the comparison between the average scores of the pre-tests within each group and the qualities of the discussions. When the average scores were divided into the 3 different levels, "100 to 150", "150 to 200" and "200-250", most of those groups that falls into the highest level, "200-250", also falls into "Detailed discussion on important points".

D. Leader Function on Chat

From the chat logs, learners who took a leader role in the chat were identified, and the relationship between the learners' rank for the pre-tests within their group and the qualities of their discussions was evaluated.

Fig. 13 shows a result of the groups of 2 people while Fig. 14 shows a result of the groups of 3 people. Based on the results, in the groups of 2 people, when those who played a leader role have less academic ability than those who did not, their discussion tends to be well. In the group of 3 people, on the other hand, when those who had the best grade within their group played a leader role, their discussion tends to be well.

E. Evaluation of Group Assignments

In this experiment, since the assignments that are submitted individually and by groups are the same, these 3 patterns can be possible as re-submitted assignments: "Re-submitted after improving individual assignment", "Resubmitted the same individual assignments as is" and "Submitted completely new". Those assignments that were made completely new include the ones that combined several different assignments. Fig. 15 shows a distribution of the ways each group made their assignment. In both groups of 2 and 3 people, the results indicates most groups "Re-submitted after improving individual assignment".

"Re-submitted the same individual assignment as is" does not serve the meaning of collaborative learning, and it also means the collaborative script did not work well. Fig. 16 shows the quality of discussion being held by groups who "Re-submitted the same individual assignment as is". Many of these groups had a discussion that was "Mostly chit-chatting" and "Pointless", so some type of scaffolding is necessary for them.

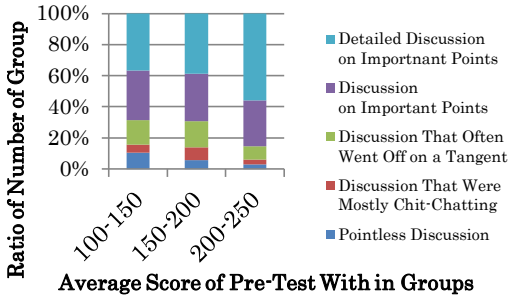

Figure 12. Pre-tests and quality of discussions

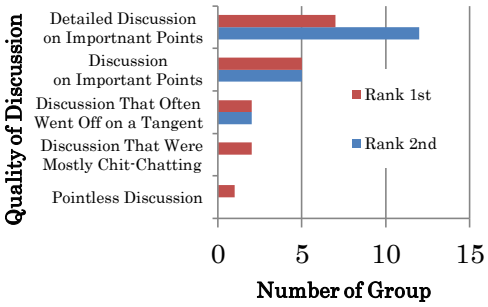

Figure 13. Leaders' rank in the group of 2 people

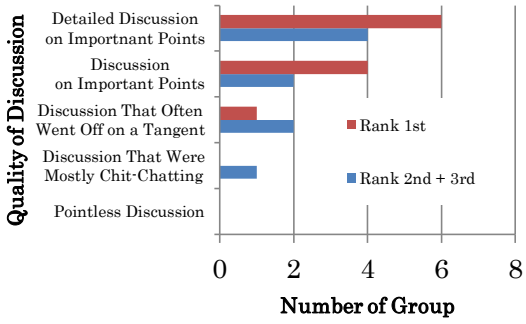

Figure 14. Leaders' rank in the groups of 3 people

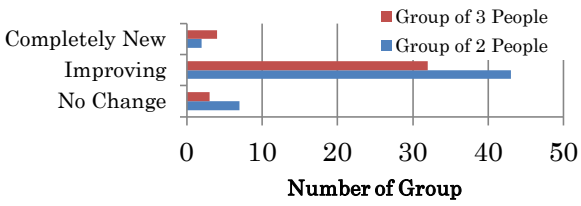

Figure 15. How they submitted group project

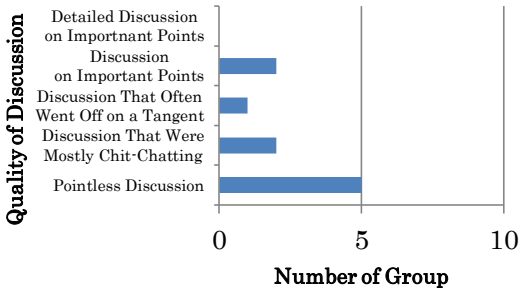

Figure 16. Quality of discussion held by groups without making changes

TABLE 7. EVALUATION STANDARD FOR PROJECT

Good	Complicated Question than the exercise shown in advance and an answer is right.
Average	Similar to the exercise shown in advance or equivalent in complexity, and a Answer is right
Bad	Similar to the exercise shown in advance or below equivalent in complexity, and an Answer is mistake

TABLE 8. QUALITY OF DISCUSSION AND EVALUATION OF PROJECT BEING SUBMITTED

	Evaluation		
	Good	Ave	Bad
Detailed Discussion on Importnant Points	13	18	9
Discussion on Important Points	3	18	6
Often Went Off on a Tangent	2	5	7
Mostly Chit-Chatting		3	2
Pointless Discussion		2	4

TABLE 9. HOW DISCUSSIONS WERE MOVED FORWARD AND PROJECT EVALUATION RESULTS

	Evaluation		
	Good	Average	Bad
Completely New	2	3	1
Improving	16	38	22
No Change		5	5

Table 7 shows a standard for the group assignment, “Good”, “Average” and “Bad”, which are used for grading. Table 8 shows a comparison between the evaluation result and the qualities of the discussions. The evaluation was done by 1 teaching staff who carried out the experiment. There were 2 different evaluators for this evaluator and the one who evaluated the qualities of the discussions. The result shows that the better the discussion quality is, the higher the assignment evaluation is.

Also, Table 9 shows a comparison between evaluation results and how discussions were carried on. “Made new” had a higher ratio of “Good” whereas “No changes” did not have any “Good”. As Fig. 16 suggests, “No changes” tends to result in “More chit-chatting” or “Pointless”. These points indicate that increasing a quality of discussion can lead to “Improvement” and “Make from scratch” with assignments highly scored.

VII. SUMMARY AND FUTURE ISSUES

A. *Summary*

Supposing a situation where a face-to-face learning is impossible, we developed a CSCL system which can form many small groups for the online collaborative learning, and then the question-posing collaborative script based on the reciprocal teaching method was implemented in the system.

Then, in the environment with 300 people, the automated group formation and the collaborative script were proved executable and effective.

(1) The learners felt that the mutual work using the collaborative script was effective. In fact, discussions through the chat were activated while keeping their quality high.

(2) Many groups improved their submitted individual assignment through discussions online. Those groups that held high quality discussions scored high on their group assignment.

(3) It is suggested that the activation of discussions depends on an academic ability of the learners who play a leader role within their group. However, depending on a group structure, higher (academic ability) does not necessarily mean good.

First, according to (1) and (2), the results showed that the design of the collaborative learning in this study was mostly appropriate.

Also, according to (3), it is important to identify the most suitable learners to play a leader role and assign them in each group. However, the characteristics of learners who should play a leader role cannot be selected based on their academic ability, such as scores of pre-tests. To resolve such issue, in the future, it is important to develop a method to identify learners with an ability to take a leader role from a pre-survey and activity logs.

On the other hand, when the collaborative script is executed in a class, it is important to plan for exceptional cases, such as students’ no attendance. Collaborative script does not allow a progress of tasks to be flexible, so the script often gets non-executable when the learning environment is off from an original plan. In this experiment, there are learners who attended on the 1st day and missed the 2nd day, or learners who missed the 1st day and

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attended on the 2nd day, so there were many groups that could not make progress their learning as planned. Also, there were some time limitations, such as a deadline for submitting assignments, so there were groups that had to submit without having sufficient discussions. Based on the above, executing a collaborative script needs some degree of flexibility depending on a learning environment and conditions of learners.

B. Future issues

In this study, the uniformed collaborative script was executed, but it is necessary to develop and practice collaborative script that is adaptable in groups in a way that the script changes flexibly depending on a group's characteristics and progress.

Also, for the automated group formation, it is necessary to be capable of forming various groups based on learners' detailed characteristics being specified and to clarify characteristics of groups depending on learners included in the groups.

ACKNOWLEDGMENT

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Web Annotation System in Collaboration with Moodle

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***Abstract*— The use of annotation has been proven to be quite effective for e-Learning. In this paper, an Ajax-based web sticky-note system was developed. The system "PnoteIt" enables the users to attach their virtual sticky-notes at any place on the web page. The users of "PnoteIt" can share their sticky-notes with other users, or hide them from others. "PnoteIt" was also extended to collaborate with Moodle, the world famous open-source Learning Management System (LMS). This extension was done in order to implement the annotation function in the "Page" contents of Moodle. The practical evaluation of our system (PnoteIt for Moodle) is in progress.**

Keywords-annotation; Ajax; Moodle.

I. INTRODUCTION

Sometimes the fact that e-Learning contents are displayed on the computer monitor becomes problematic for learners. When the learners use paper-based textbooks, they can write their comments in the textbooks as they like. These written comments can help learners to understand the subjects. However, in the case of e-Learning, such comment-writing is not possible. This situation can be improved when the "annotation" tools are introduced into the e-Learning system. Moreover, the "annotation" tools are not only used for personal comment-writing, but also for collaboration between learners.

We have given lectures at Kanazawa Institute of Technology for nine years with Moodle [1], which is probably the most famous open-source LMS (Learning Management System) in the world. We faced the same problem discussed above, then searched for an annotation module for Moodle and found "A.nnotate" [2]. This module enables "Teacher" users of Moodle to add their comments and feedbacks to the Portable Document Format(PDF) and Word documents. However, the annotatable documents are restricted to the contents of "Assignment" of the "Student" users. In addition, "A.nnotate" cannot manage the collaboration between students. Hence, the "A.nnotate" is not suitable for our purpose.

In 2009, we developed a web annotation tool named "PnoteIt" [3] for the use of the management of "KIT Mathematic Navigation" [4], which is a math-education website for high-school, college and university students. Thus. we came to the idea of the collaboration between PnoteIt and Moodle.

In this paper, the annotation in e-Learning is briefly reviewed in Section II. Section III is dedicated to the explanation of "PnoteIt for Moodle" system which we developed for this study. In section IV, we show the result of the usability evaluations for the proposed system. we summarize this study in Section V.

II. ANNOTATION IN E-LEARNING

The use of annotation has been proven to be quite effective for the e-Learning. For example, Farzan and Brusilovsky [5] showed that their system "AnnoteEd" is quite effective for collaborative learning. This article also presents a comprehensive review for similar studies. The annotation of the "AnnoteEd" system does not seem to be located in the contents, but only beside the contents.

Nunes et al. [6] developed and examined their highlight annotation tool. The users of this system can add/share annotations by marking some sentences of the online textbook. However, they cannot write any memo or note in the textbook.

"Writable Web" developed by Kunimune et al. [7] is quite powerful annotation tool for learning materials. This system enables users to add/share their notes, marking and freehand drawing at any place on the contents. However, the possibility to realize the collaboration between "Writable Web" and Moodle is unknown.

Moodle is currently very popular in the world. If there is an annotation system which is adapted to Moodle, it will enhance the availability of the Moodle and also help Moodle users extensively. Therefore, we intended to adapt "PnoteIt" to Moodle. In the following section, we present a detailed explanation of the "PnoteIt" web sticky-note system and its collaboration with Moodle.

III. PNOTEIT FOR MOODLE

"PnoteIt" originated from Perl-based Ajax/Common Gateway Interface(CGI) program "NoteIt" developed by Baba [8]. We rewrote "NoteIt" in PHP+MySQL manner which becomes more popular than Perl CGI currently and called "PnoteIt". We also added multi-user function through the development of "PnoteIt". This system has been used for the management of the "KIT Mathematic Navigation".

The original "PnoteIt" has its own user registration/authentication function. The management of that function is available only for the administrator user. The users can use sticky-note function after they logged in the system unless the administrator permits the "Guest Access" at the configuration. The users can share their sticky-notes with other users, or hide them from others though the administrator user can completely see and manage all sticky-

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notes attached by all users. In the process of the adaptation of "PnoteIt" to Moodle, we omitted the user registration function and integrated authentication with Moodle's. By checking the user's capability, the administrator function is automatically assigned if the user has a "Teacher" role of the course which includes "PnoteIt"-enabled contents.

To add the sticky-note function into the contents of the "PnoteIt"-installed website, the author must add the following one-line "PnoteIt code" to the "body" in the HTML source of the contents is needed:

```
<script type="text/javascript" src="/pnoteit/pnoteit.php"></script>
```

Here, we supposed that the "PnoteIt" system files are placed into "(webroot)/pnoteit/" directory. This modification must be iterated over the sources of all pages on which we intend to enable sticky-note function. These are similar for the case of "PnoteIt for Moodle" environment. Once the "PnoteIt code" is added in the source, the "PnoteIt Toolbar" appears in the webpage (Figure 1.).

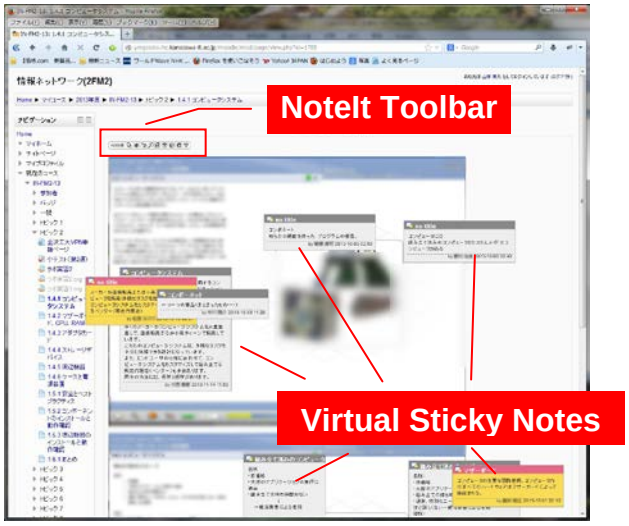

Figure 1. Example Screenshot of "PnoteIt for Moodle".

The draft sticky-note appears when the users double-click the place where they intend to attach their annotation in the contents. After the insertion of the title and text, the attachment of the sticky-note is completed by clicking the "OK" button. If the user double-clicks the existing note, he/she can edit the title or text of the note unless it is locked. The sticky-note can be moved to any place by drag-and-dropping, but the position is restored when the page is reloaded unless the sticky-note is "fixed". Usually, the name of the "owner"(who makes the note) and the date when the note was attached are shown in the individual sticky-notes, but the sticky-note management menu appears when the mouse pointer is on the note (Figure 2). The "owner" can resize, fix, delete, lock/unlock and change the color of the sticky-note with this menu. By default, the sticky-note is "Private" - only visible to the "owner" user, but the "owner" can toggle the accessibility of the sticky-note by clicking the icon at the upper-left corner of the note. If the "owner" makes their unlocked note "Public", any user can edit it freely.

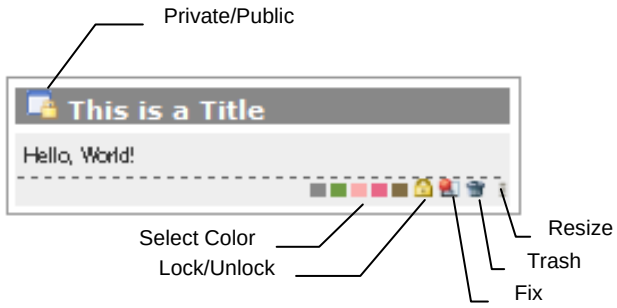

Figure 2. Sticky-Note Management Menu.

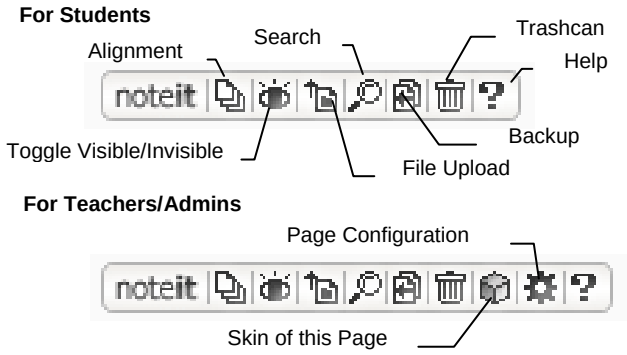

Figure 3. NoteIt Toolbar.

The menu provided by "NoteIt Toolbar" (Figure 3) includes "Alignment", "Toggle Visible/Invisible", "Search", "File Upload", "Backup" and "Trashcan". "Skin of this Page" and "Page Configuration" menu is added if the user has an "Administrator" or a "Teacher" role. When the user clicks the "Alignment" icon, all of the visible notes are aligned at the left-hand side and sorted by date. But they can go back to the original places by reloading the browser. All of the visible notes can be temporally invisible if the user clicks the "Toggle Visible/Invisible" icon. The full-text search of all visible notes in the page is available with "Search" function. Image files uploaded by "File Upload" function can be also shown in the sticky-notes. When the collision (two or more users edit one shared note simultaneously) occurs, the users should check the history shown in the "Backup" window. The "owner" can restore the deleted notes from "Trashcan". The administrator/teacher can configure the "Skin" and inhibited word/host of the page with "Skin of this Page" and "Page Configuration" functions.

The install procedure of "PnoteIt for Moodle" is the following: 1. Create the directory named "pnoteit" in the Moodle's wwwroot directory and place all files of "PnoteIt for Moodle" in them; 2. Configure the place of the "config.php" of Moodle and directory permission correctly. The tables specific to the "PnoteIt for Moodle" are automatically created if they does not exist in the Moodle database. We have confirmed that my system works well with version 1.9.16 and 2.5.3 of Moodle.

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IV. USABILITY EVALUATION

After the development of “PnoteIt for Moodle", we conducted the usability evaluation based on the WUS (Website Usability Scale) advocated by Nakagawa et al. [9]. 18 samples that are 4th year students of Kanazawa Institute of Technology and are also Moodle users answered the questionnaire after 3 hours trial use of “PnoteIt for Moodle". Each question is answered by 1 (negative) to 5 (positive) point scales. The results are shown in Table I.

TABLE I. RESULTS OF USABILITY EVALUATION

Question	Average Score
I think that I would like to use this system frequently:	4.1
I think this system is useful:	4
I think this system is reliable:	3.4
I think this system is easy to use:	3.5
I think this system can support the lecture:	3.7
I think this system is readable:	3.6
I think this system is responsive:	4.3

It is obvious that the evaluation scores of the reliability, operation and readability are relatively low. According to the oral communication with some sample students, we found that this result might be partially due to the sticky-note attachment method which requires slightly complicated steps (1.double-click the contents; 2. insert title and text; 3.press "OK"). This procedure should be simplified in order to improve the usability. Some sample students also claimed that the way to move the sticky-notes was confusing. A sticky-note can be moved to any place in the contents by drag-and-dropping, but when the user reloads the browser it goes back to the initial position unless it is not fixed. Such behavior is counter-intuitive. Therefore, the implementation of the automatic position fixing of a sticky-note seems to be necessary. Low readability score might be caused by the small fonts of the title/text in the sticky-note.

V. CONCLUSION AND FUTURE WORK

We developed an annotation tool named "PnoteIt" that can collaborate with Moodle, the world famous open-source LMS. The user can attach their virtual sticky-notes at any place in the HTML based learning contents. The results of the usability evaluation suggested the improvement of some operation method and readability. Currently, we are planning to adapt "PnoteIt for Moodle" to the plug-in module of the Moodle in order to ease the installation.

"PnoteIt for Moodle" is currently used in our class "Information Networks" of the 2nd semester. 79 students enter the course and about half (not all, unfortunately) of them are attaching their sticky-notes on the learning contents. The educational effect of "PnoteIt for Moodle" will be evaluated after the end of the semester by comparison with other class of "Information Networks", which does not use "PnoteIt for Moodle".

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Peer-to-Peer Communication for Computer-supported Collaborative Learning

The PeCoCC Framework

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***Abstract*— Computer-supported collaborative learning is an important domain of e-learning dealing with researching efficient methods to encourage the people to learn together with the help of their computers. The learning environments used in this domain are usually client-server based solutions with some extra functionality needed for the collaboration between the members. Because of its architecture, which is similar to the collaborative learning network, the peer-to-peer (P2P) technology is suggested as a better solution. This paper introduces a P2P-based framework for applications in the area of computer-supported cooperative learning. This framework embodies a platform for P2P learning applications and consists of four different layers. It includes different P2P modules and chooses the module that works best according to the application requirements. The paper shows the advantage of the proposed framework.**

Keywords-Peer-to-peer communications; computer-supported collaborative learning.

I. INTRODUCTION

During the last decade, online learning has gained enormous interest in most educational institutes. E-learning can be defined as the process of using electronic media, information and communication technologies in education. E-learning includes numerous forms of educational technology in learning and teaching and can be used jointly with the conventional face-to-face learning. E-learning can occur in or out of the classroom. It is suited to distance and flexible learning and can be asynchronous or synchronous. As a result of the rapid improvement in the areas of education, information and communication technologies, various e-learning forms have evolved. This evolution started with using the information technology in the Computer Based Training (CBT) and develops in the direction of exploiting the internet and social interaction in the Virtual Learning Environments (VLE) and Computer-Supported Collaborative Learning (CSCL) applications [1].

The most used learning environments were based on the client/server approach. A server is the source of services and information, several clients have access to. However, the approach suffers from two main problems: scalability and single point of failure. Thus, different approaches to overcome these problems have been developed. One of these is a paradigm shift to the P2P model. In this approach, the communication partners act as server and client at the same time. They all offer a part of the information and retrieve information from other nodes known as peers. The more peers take part in a P2P communication, the better this network scales and the higher its reliability is. Several application fields have utilized this P2P approach so far. In this paper, we introduce a framework to apply this approach for computer-supported collaborative learning.

Therefore, the paper is organized as follows: Section 2 shortly deals with computer-supported collaborative learning and reviews some CSCL-tools based on P2P technology. Different P2P technologies and their properties are analyzed in Section 3. Section 4 presents our designed CSCL-tool, the **pe**er-to-peer **co**mmunications for **c**omputer-supported **c**ollaborative learning (PeCoCC) framework and its functioning. Section 5 gives an overview of the current state of the work and summarizes the paper.

II. PEER-TO-PEER COMPUTER-SUPPORTED COLLABORATIVE LEARNING

Computer-supported collaborative learning is an emerging branch of e-learning allowing several students to cooperate with each other and with the teaching staff online in order to solve shared tasks or to exchange their skills. Computer-supported collaborative learning is related to collaborative learning and Computer Supported Cooperative Work (CSCW). By collaborative learning we generally mean that a group of students work together to discuss, solve or evaluate teaching materials; on the other hand, computer supported cooperative work addresses the technologies and tools supporting people in their work. Hence, computer supported collaborative learning refers to the use of CSCW- technologies and tools by a group of collaborative students in a learning process. These technologies and tools have been developed to provide an efficient learning process. Woodill [2] gives an overview of all the different technologies used to support collaborative learning (see Figure 1).

As mentioned above, one of the suggested approaches to overcome the problem of the client-server model in collaborative learning is using the P2P technology. There is already some research work done in this area. Some educational P2P applications like, e.g., COMTELLA, EDU-

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COSM, Edutella, and Groove have been developed for some specific needs and they are still under development

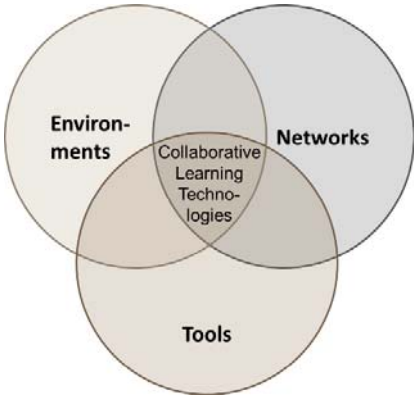

Figure 1. Information technologies used to support collaborative learning [2]

COMTELLA is a P2P file sharing system that allows students to contribute and share class-related resources with their community [3]. The shared papers are annotated with respect to their content in categories. COMTELLA uses a modified version of the Gnutella P2P protocol and instead of sharing the actual files, only their URLs are shared. A list of the shared articles, their URLs in the web and the corresponding comments are distributed among the users. There is one list for every category. If a student searches for a paper, he should only search the list of the matching category. Students can view and read the papers without downloading them by clicking on the "Visit" button in the COMTELLA user interface, which starts the default browser with the URL of the paper.

EDUCOSM is a web-based learning environment providing a shared view to the Web [4]. It consists of a collection of server-side scripts and an HTML and JavaScript based client that runs inside a web browser. The role of the server is to store the data and act as a proxy between the client and the rest of the web. The principles of EDUCOSM and COMTELLA are similar with the difference that the storage of the data in COMTELLA is distributed among the users.

Edutella is an educational P2P network built on Sun Microsystems JXTA Framework [5]. Edutella is an open source P2P application for searching semantic Web metadata. It uses the resource description framework (RDF) for presenting information in the web. Edutella deals with metadata about content, not with content itself. It adds a search service to the JXTA framework, so that any node that carries metadata about some resource can announce an Edutella search service to the network. The nodes in Edutella have actually at least one of three types of roles: provider (provides a query service), consumer (asks questions) and hub (manages query routing in the network).

The previously mentioned three P2P collaborative systems offer only one collaborative tool, mostly a file-sharing application, which is not sufficient for efficient collaboration among the users. These systems suffer the absence of a coordinative tool like a group calendar which is typical for team or group software. They also do not support cooperation applications like a whiteboard or a text editor.

These problems have been tried to be solved in one of the popular collaborative environments, Groove. It is a collaborative groupware based on the principle of a shared workspace [6]. Tools like a shared browser, a shared drawing board or a file archive are used to operate in this shared workspace. Groove provides servers that are used to detect new peers in the network and to store content if one or more peers are offline and cannot see the changes made at that time. Using server-based services threatens the availability of these services if one of these servers fails.

Groove is targeted at small workgroups and has its own protocols. It is only available for the windows platform, so it suffers interoperability problems. This manifests the need for a collaborative environment providing many collaborative and coordinative tools, supporting interoperability, and basing on fully distributed server-independent P2P communications and services. However, there is no open source software having the mentioned functionalities available at the moment.

III. PEER-TO-PEER TECHNOLOGIES

In contrary to the client-server model, all the members of a P2P network are equally offering and requesting services. Generally, we can assert that every P2P network is established on an overlay network, mostly based on Transmission Control Protocol (TCP) or on Hypertext Transfer Protocol (HTTP) connections. Thus, the overlay and the physical network can be separated completely from each other. Hence, the overlay connections do not reflect the physical connections. Nevertheless, it is possible to match the overlay to the physical network if necessary. P2P networks can be divided into two classes: unstructured and structured P2P networks.

In a structured P2P network, the network topology and the location of content is determined by employing a P2P protocol. In these networks, the content and the participating nodes share the same address space which makes it easy and expeditious to reach any content in this space. Structured P2P networks are based on a Distributed Hash Table (DHT) and have no central entities. Frequent signaling traffic is necessary to maintain the network awareness of the nodes. Pastry, Chord and Content Addressable Network (CAN) are examples for this class.

The distribution of nodes and content in unstructured P2P networks is executed randomly. The position of content can only be resolved in a local proximity of a node and only by flooding the request to a particular extent. In this way, these networks consume the bandwidth, which has been saved by their random distribution. Unstructured P2P networks can be centralized with an index server like Napster, hybrid with dynamic super nodes like Gnutella 0.6

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and JXTA, or pure without any central entities like Gnutella 0.4 and Freenet [7].

IV. THE PECOCC FRAMEWORK

Until now, most P2P collaborative environments are developed for specific needs and a central entity is used in most of them. Therefore, we have developed a P2P framework for computer-supported collaborative learning, which we called PeCoCC. The PeCoCC framework uses different P2P overlays to support different applications. This characteristic of the PeCoCC framework enables completely separate working of the applications, which increases the robustness of the system. The PeCoCC framework has a layered architecture depicted in Figure 2.

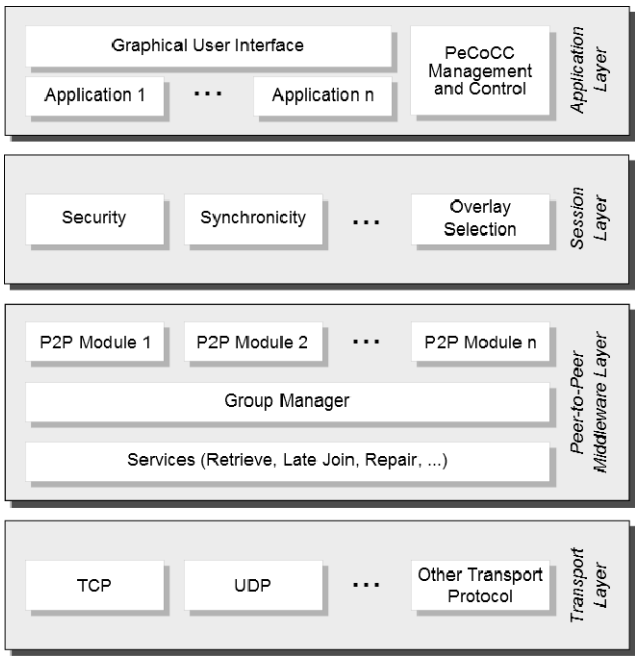

Figure 2. The PeCoCC framework

The main functions that this framework has to provide are as follows:

Collaborative Tools – the PeCoCC framework provides three applications, which are important to cooperate efficiently. A shared calendar will be used to allow the users to organize their regular meetings; a distributed text editor can be used to jointly make notes on a given subject or to brainstorm about a topic and P2P file sharing allows users to access the distributed contents they need to cooperate.

Group Management – The framework must include functions to manage the communication among collaborative group members.

Recovery – The framework implements a "late join" mechanism to consistently provide the information for latecomers to enable them to participate in the ongoing session. This is typically achieved by getting the state of the distributed application from the current participants and by initializing the application of the latecomer with this information.

Synchronization – For some application modules (e. g., distributed text editor), the group members need to be synchronized to interpret the events in the correct time and order.

Security – The framework provides security mechanisms (e. g., encryption) to keep personal data integer and secure.

The PeCoCC framework consists of four different layers, which support its main functionalities. The layers are introduced in the next subsections.

A. Application Layer

The application layer consists of three main parts. The graphical user interface allows the interaction between the user and the framework. It facilitates a consistent operation of all the desired CSCL services. The PeCoCC Management and Control (MC) module is responsible for controlling the data flow through the framework and the work flow among the users. It influences the application program and also saves a list of the cooperating participants, their application-dependent roles and their priorities. The peers should be identified by the MC module to be allowed to enter the system. The rights of the users can be defined by the applications themselves. In a file sharing application, for example, all the users have equal rights, while in a text editor, the teacher should have more possibilities to manipulate the entered information than the students. Furthermore, in sessions without a dedicated chair, the MC module is responsible for defining the user that has the according rights of a chair.

The third part is composed of application modules. These can be freely chosen and added on demand. As stated above, the first modules of our choice are a distributed text editor application, a calendar, and a file sharing application. These modules interact with the graphical user interface and the MC module.

B. Session Layer

The session layer provides general mechanisms that are necessary for the offered applications. Currently, we have concentrated on two mechanisms. The security module is responsible for securing private user data and the synchronicity module, which provides a mechanism to synchronize the different group members so that all of these receive the events in the same order. This service is necessary for real time applications like a distributed text editor. Since the using of P2P overlay in the PeCoCC framework is application dependent, the session layer includes the Overlay Selection (OS) module, which is responsible for saving the information about the appropriate P2P overlay for each application.

C. Peer-to-Peer Middleware Layer

As P2P technologies exist with respective advantages and disadvantages, the PeCoCC framework allows the usage of different pure P2P technologies. Each technology is

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encapsulated in a P2P module and offers its communication functionality. Which module should be used is selected by the OS module in the session layer according to the needs of the application. To illustrate the functionality of this layer, we have started with two well-known P2P approaches. The content addressable network (CAN) can be used for an efficient distribution of information and teaching materials. It is a structured P2P network based on DHT. CAN offers high scalability and reliability and provides more load balancing than any other pure P2P overlay [8], but it does not take into account the underlying network conditions. Therefore, it is not suitable for real-time applications due to the fact that it does not make any correlation between the overlay distance and the actual number of unicast hops between the hosts in the underlying network. PASTRY, another structured P2P network considers the underlying network topology and supports a scalable and distributed object location and routing in application layer [7]. The PASTRY protocol can thus be integrated in a P2P module for applications like a distributed text editor and instant messaging.

Furthermore, in each network the users belonging to one user group have to be managed. This is done in the module called group manager. This module is responsible for forming and supervising a collaborative user group. Finally, this layer comprises a set of services that extend the P2P modules with late join, retrieval and repair functions.

D. Transport Layer

The transport layer provides access to different commonly used transport protocols. These are selected accordingly to the requirements of the applications. For example, the distributed text editor utilizes the Transmission Control Protocol, which provides a reliable transport service.

E. Functioning of the System

When the user starts one of the available applications (e.g., a distributed text editor), the MC module is activated and sends a CHOOSE message to the OS module in the session layer containing information about the opened application.

The OS module then decides on the basis of the opened application which P2P module is more appropriate for this application and replies to the MC module in the application layer with an OVERLAY message. The OS module also activates the necessary services for the opened application.

The MC module receives the OVERLAY message and retrieves the saved list of the expected participants (the participants of an application should be previously registered by the MC module and saved in a specific list). The MC module then sends a START message to the corresponding P2P module in P2P middleware layer.

In the P2P middleware layer, the selected module starts the P2P connection and sends a DISCOVERY message to find out if the P2P network has already been built or not. If it gets an answer, it will take part in the P2P network. The group manager then sends a JOIN message with the group ID using the overlay multicasting protocol to join a collaborative group and retrieve the information about the participating peers as well as the important data to interact in the current session. If a collaborative group does not exist, the group manager will send a CREATE message in the P2P network to create a collaborative group with a specific group ID.

The information retrieved by the group manager from the members of the group is returned to the MC module to specify the role and the rights of the peer in the session. The role of the peer will appear in form of active or inactive interaction possibilities in the user interface.

Which rights and roles the user has, is managed in tables and saved in the MC module. One table is defined for each application. In the case where all users have the same rights, a mechanism to manage and identify the roles will be used. This mechanism can take into account the registering sequence of the participants or the alphabetic order of the user ID names, etc.

V. CONCLUSION AND FUTURE WORK

In this paper, an overview about the current P2P collaborative environments and their use case has been presented. The P2P technologies have been briefly highlighted. We have also introduced our PeCoCC framework to allow computer-supported collaborative learning based on pure P2P networks that provide fully distributed and server-independent P2P communications and services, which increase the availability of these services and solve the problem of single point of failure present in server-based systems. The PeCoCC framework is still in implementation phase. It supports the interoperability and is being implemented in Java using the integrated development environment eclipse. A distributed text editor is being built on the top of the PASTRY algorithm and is using the PASTRY overlay multicasting protocol SCRIBE. To evaluate the performance of the framework, a P2P simulator named Peerfactsim.KOM will be used. This simulator has a similar layered architecture like the PeCoCC framework and supports many forms of messages to communicate among the layers in the host. It is also implemented in java and it offers a user-friendly graphical user interface [9]. In the future, a file sharing application will be built on the top of the content addressable network P2P algorithm. A mechanism for structured metadata will be needed to fulfill the educational purposes in P2P networks.

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Creating a Global Classroom Using a 3D Technology to Enhance Language Development

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Abstract—**This study reports on the findings of a case study with English language learners and special education teachers who met in Second Life for conversation practice. The English language learners had a much more positive attitude towards the usability of Second Life for language learners than the special education teachers. Findings suggest that language instructors teaching in a three-dimensional immersive virtual world must be equipped with unique teaching skills. Interaction among conversation partners must be maximized to ensure a successful language learning experience. The lesson design must be carefully planned to take full advantage of the potential of virtual worlds and their relatively authentic and contextualized settings. A virtual world may be conducive to oral fluency enhancement, provided that activities are set up appropriately and there is ample support from the instructor. Extensive challenges inherent to the lesson design and audio quality were identified. Guidelines on how to address these challenges are addressed. These findings will be relevant to other language instructors who plan to use Second Life for oral fluency enhancement.**

Keywords-Second Life; virtual worlds; second language acquisition; oral fluency; collaboration; conversation partners

I. INTRODUCTION

This article reports on an investigation of the usability of Second Life, a highly compelling visual and immersive virtual world, to improve English language learners' (ELLs) oral fluency by engaging them in purposeful interaction with English native speakers. Oral fluency is a complex, difficult-to-measure construct. It has been defined as the ability to produce language without undue pauses or hesitations [1]. Four types have been identified [2]. These include the ability to (i) fill time with talk, (ii) produce logical and semantically dense language, (iii) have appropriate things to say in a wide range of contexts, and (iv) express oneself in a creative and imaginative way, using a wide variety of alternative linguistic devices and choosing the one that is most situation appropriate.

The current study is situated in a three-dimensional immersive virtual world. Schroeder's [3] definition of virtual reality is "a computer-generated display that allows or compels the user (or users) to have a sense of being present in an environment other than the one they are actually in, and to interact with that environment". Educational platforms can be found in the areas of astronomy, medicine, music, literature, biology, history, mathematics, forensic science, ecology, and tourism, to name a few.

Second Life provides a powerful platform for situational language practice. The most recent studies, which include a literature review [4], three qualitative studies [5-7], four quantitative studies [8-11], and one mixed-methods study [12], indicate that a virtual world can assist language learners by extending the traditional language classroom. It provides an environment for stress-free, one-on-one oral practice through activities, such as role-playing, discussions, presentations, debates, games and simulations. English language learners, in particular Chinese students, have been shown to be apprehensive of spoken communication for fear of being negatively evaluated [13]. In a similar vein, the results of a study by Wehner et al. [12] suggest that virtual worlds may help to reduce student anxiety and increase their motivation to learn a foreign language. Virtual worlds could be an effective way to help Chinese ELLs overcome these fears and inhibitions [11].

The current study contributes to the research about language learning in virtual worlds by identifying students' and special education teachers' perceptions of Second Life as a language learning platform, as well as the unique teaching skills required. In addition, the study investigates potential challenges and the effects of virtual meetings on ELLs' perceptions of their oral fluency. Continued research on virtual worlds is necessary to yield stronger teaching models that guide educators in the optimal use of virtual worlds for language instruction [6]. As more educators and researchers develop pedagogical models for best practices in language learning in virtual worlds, taking advantage of such resources will become easier [6].

Recent studies in the field of second and foreign language acquisition will be reviewed in the next section, followed by the purpose of the present study. The sample, the six data collection instruments, the procedures, and data analysis will be described in the method section. Results will be organized around the instruments and will be presented from the perspective of both the ELLs and the special education teachers (SPED). The discussion and conclusion section is organized around the research questions and concludes with the study's limitations and suggestions for future research.

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II. LITERATURE REVIEW

Through interactions with target language speakers in Second Life, ELLs can benefit from immersive language practice; tasks for learners at all levels can be designed [6]. Second Life has been shown to offer an "interactive, immersive and content-rich virtual environment for input, interaction, task-based learning and output production" [6]. Virtual worlds offer a suitable platform for synchronous language interaction and the opportunity for conversation and collaboration between language learners and native speakers of the target language.

Wang et al. [11] investigated effective and practical ways to integrate Second Life into an English as a Foreign Language (EFL) program for students in Chinese universities, in which Chinese students conversed with American native speakers. Many study participants reported having a positive attitude towards using Second Life for language learning and perceived the collaboration with their American conversation partners as interesting, effective, and helpful in improving their English skills. Meaningful and authentic interactions with the American students were identified as key motivational factors. Once the Chinese students were immersed in Second Life, they demonstrated more active and sustained speaking events, which helped them to improve their communicative abilities. Their positive experiences were, however, tarnished by technical problems, including poor audio quality (echoing and interrupted audio) and frozen screens to an extent that they seriously interfered smooth communication and task completion in Second Life. Wang et al.'s recommendations for facilitating language learning events in Second Life include: preparing students for task completion, setting a time limit for any given task, closely monitoring student language performance, encouraging post-task reflection, and providing feedback. Overall, the collaboration was found to enrich both the cultural experience and the communication with virtual conversation partners.

Similarly, Knutzen and Kennedy [9] reported on a partnership between ELLs in Hong Kong and student teachers enrolled in a Teaching English to Speakers of Other Languages (TESOL) program at a university in the United States. The two groups met in Second Life at a virtual American diner and communicated through text-chat and voice. Among the conditions that resulted in the most productive interactions was the use of voice communication to practice speaking and listening, as well as the use of separate sound parcels in the form of Cadillac diner booths to allow private conversations. Wehner et al. [12] investigated the relationships between motivation, virtual worlds, and foreign language acquisition. One section of a Spanish course used Second Life as part of its instruction, while the other section participated in the traditional curriculum. Overall, the group using Second Life consistently reported more positive feelings in all areas of motivation and lower levels of anxiety.

Ishizuka and Akama [14] highlighted the potential of Second Life for second language acquisition. Good scenarios and controlling learning environments based on second language acquisition theories have the potential to change language teaching and learning [14]. Several attempts to use Second Life for language learning have been made in the past. A number of EU-funded, large-scale projects include the Access to Virtual and Action learning Live Online (Avalon) project, the Networked Interaction in Foreign Language Acquisition and Research (NIFLAR) project, and the Talk with Me project. These projects aim to facilitate cross-cultural language learning by taking advantage of virtual worlds to simulate communicative acts and provide information on learning models and practices using Second Life as a language learning platform [14].

The current study reports on the findings of an exploratory case study with two groups. International students enrolled in an ELL program and SPED teachers studying at the same university in the United States met in Second Life for conversation practice. The overarching question that framed this research was to identify the usability of Second Life for oral fluency enhancement. The study was guided by the following research questions:

1. What are the English language learners' and the special education teachers' perceptions of Second Life as a language-learning platform?
2. What are the unique skills that a teacher should have to teach in Second Life?
3. What types of problems associated with the language instruction in Second Life were identified?

III. METHOD

A. Sample

Twelve ELL undergraduate students at a university in California and 18 special education teachers enrolled in a graduate course at the same university participated in this research. Prior to this study, a needs assessment was conducted to identify the ELLs' performance gap in terms of oral fluency. It revealed that many Asian, particularly Chinese, students at this university are experiencing a performance gap between their actual oral proficiency in American English and the proficiency they need to fully contribute to class discussions and be understood when they speak. The ELLs were teamed up with 18 SPED teachers as their conversation partners.

B. Data Collection

Six different instruments were used for data collection. The two groups, ELLs and SPED teachers, each received a different set of the following instruments: a preliminary survey, a mid-reflection, and a post-survey. The preliminary survey was completed after watching a 5-minute video showing a tour of the National Oceanographic and Atmospheric Administration (NOAA) Second Life region and prior to the two virtual meetings. The purpose of these meetings in Second Life was to provide the teams with conversation practice. In the preliminary survey, the ELLs and the SPED teachers were asked about demographic information, their technology background, and their perception of the usability of Second Life as a language-

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learning platform. In addition, the ELLs were asked to share their perceptions of their oral fluency in English, their attitude toward English native speakers, and their perception of their motivation and self-efficacy in learning and speaking English. Participants replied to the mid-reflection prompts after the first of two meetings in Second Life. The prompts were designed around the research questions and provided an opportunity to reflect on the usability of virtual worlds for language learning. The post-survey offered an opportunity to reflect on the experiences after the second virtual meeting. Respondents were expected to be able to make informed decisions about the usability of Second Life for language learning after the two virtual meetings.

C. Procedures

The two groups, ELLs and SPED teachers, were each introduced to Second Life by their instructors, respectively. The SPED teachers, for instance, spent 30 minutes in Sploland as a class to explore the region and experiment with hands-on activities and then teleported to Spaceport Alpha for a short fieldtrip. The purpose of these preliminary fieldtrips was to provide students with a chance to familiarize themselves with navigation and voice communication. The instructor was physically present in the computer laboratory, while the second author joined the group in-world as a facilitator.

Next, a small group of ELLs met in Second Life with a small group of SPED teachers on EduNation. ELLs and SPED teachers met twice for one to two hours each. Sound checks were conducted before the meetings. All participants were required to use USB headphones. The meetings were organized by an external English instructor, who was commissioned to design and lead the workshop because of her specialization in teaching ELLs in Second Life. Examples of the activities include: playing domino to increase vocabulary, a scavenger hunt which entailed describing interactive household items in the instructor's virtual house, a TV quiz show in a TV studio, playing taboo, a grammar rummy, and a murder mystery.

D. Data Analysis

In this exploratory case study, the qualitative data, which emerged from the preliminary survey, the reflection, and the post-survey, have been used to gain insight into the personal reflections and perceptions of the participants. Emerging themes were identified through open-coding and were combined into recurring patterns. Quantitative data from the surveys inform the story and substantiate the qualitative information.

IV. RESULTS

The results have been arranged chronologically.

A. Preliminary Student Survey (ELLs)

The sample consisted of 12 ELLs between 18 and 21 years old. Most students' mother tongue was Chinese. These learners reported relatively good aural comprehension in English, but difficulty understanding conversations among their English-native peers. Most, however, reported struggling to express what they want to say, rarely speaking up voluntarily in English, and lacking the confidence to do so. All, but one, reported that they believed they could be understood mostly well. When asked about the reasons why people may have difficulty understanding them, 87% reported that it was due to a lack of vocabulary. On average, respondents' motivation to learn English was 5.4 on a 7-point rating scale (1=weak, 7=strong). On average, their attitude toward English native speakers was 5.7 (1=unfavorable, 7=favorable). Most respondents (67%) reported that they were not nervous when they had to speak English to someone they just met, while 33% reported being somewhat nervous. On a rating 10-point rating scale, they self-reported their technological expertise at 7.33 (1=lowest, 10=highest). In terms of 3D virtual worlds, 76% reported having no or little experience. Seventy-three percent agreed that they did not have to worry about losing face in Second Life because their conversation partner could not see their real face. In the same vein, 80% replied that the use of an avatar in Second Life made them feel more at ease because it helped them disguise themselves.

B. Students' Mid-Reflection (ELLs)

The mid-reflection was completed after the first virtual meeting with their native English-speaking partners, that is, the SPED teachers. All ELLs reported finding the virtual meeting with their English native speaking partners useful. They all appreciated the opportunity to practice speaking in a relaxed environment. It was mentioned that the virtual environment may have helped to overcome shyness, to save face even when mistakes were made, and that they felt more comfortable speaking in an online setting than face-to-face. Being able to make friends, engaging in interesting interactions in a relaxing, game-like, and visually appealing environment were factors that they liked.

The activities in Second Life, however, could have been more interesting, entertaining, and interactive. There were too many people at the same place at the same time (lack of functioning sound parcels) and it was hard to understand each other and the teacher. For example, due to poor sound quality and interference, instructions were unclear and the Second Life platform was too complicated. ELLs would have liked to practice pronunciation, grammar, more activities, and to have separate sound parcels for private conversations. Despite these challenges, the average rating of the usability of Second Life for language learning on a scale from 1 (useless) to 10 (excellent) was quite high at 7.7. Most students were looking forward to the second meeting.

C. Students' Post-Survey (ELLs)

In contrast to their answers in the pre-survey, no one reported difficulties in understanding their native-English speaking partners. No one reported difficulties in expressing their own thoughts and opinions in English. Everyone was confident that they were able to express the full nuance of their thoughts and opinions to varying degrees (very confident: 33%, quite confident: 50%, moderately confident: 17%). On average, respondent's motivation on a 7-point rating scale (1=weak, 7=strong) was unchanged at 5.4. The

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statements about being nervous when they had to speak English to someone they just met were almost unchanged, compared with the pre-survey. The majority (58%) reported technical difficulties.

Most students reported sound issues. Even when they did have sound, some voices could not be heard clearly. Some students were frequently logged off and lost valuable time having to log in again or having to restart their computer. As in the preliminary survey, all students, but one, agreed that the use of an avatar in Second Life made them feel more at ease due to the anonymity. All students found Second Life easy and interesting to use and confirmed its usability for language learning, although 83% stated that Second Life was not necessary for the type of language practice they had experienced. Everyone enjoyed interacting through their avatar. Benefits of using Second Life for speaking practice were identified as: communicating without seeing each other, more opportunities to meet native speakers, reduced nervousness, increased confidence, and overall more opportunities to speak than in real life. When asked what the ELL instructor, who conducted the activities, could have done differently, several students stated that they would have liked more opportunities to speak with their partners and more interesting activities. All students reported being satisfied with the experience and encouraged the instructor to keep using Second Life as a language-learning platform.

D. Preliminary SPED Teacher Survey

Eighty-three percent of the SPED teachers reported having little or no experience using virtual worlds. The average self-rating in terms of "tech-savvyness" on a 10-point rating scale (0=lowest, 10=highest) was 7.1. The average rating of Second Life for education on a 10-point rating scale (1=useless, 10=extremely useful) was 6.28, based on the NOAA video they watched. Overall, their first impression of Second Life was that it had potential for education and seemed user-friendly. When asked what they hoped to gain from the two virtual meetings with their ELL partners, most said they hoped to identify the best techniques to work with ELLs and to see some of the educational applications of Second Life from a more active role, rather than just being a student in it.

E. SPED Teachers' Mid-Reflection

Nine out of 18 SPED teachers submitted the mid-reflection. Their usability ratings went down from 6.28 (preliminary survey) to 4.33 (after the first virtual meeting with their ELL partners) on a 10-point rating scale (1=useless, 10=extremely useful). The ratings ranged from 1 to 10. Eight out of nine respondents did not find the first virtual meeting useful in order to get teach experience and provided several reasons. The set up (i.e., planned activities) failed to encourage discussion among the two groups. There were too many people and it was hard to talk because everyone else could be heard too. Although each team worked in a separate room of a house, for example, the lack of (functioning) sound parcels resulted in the participants hearing everyone speak, which made it challenging to identify one's team members' voices. Separate sound parcels would also have satisfied the participants' desire for private communication. More interaction and better time management would have been appreciated. The following statement describes the amount of spoken interaction between SPED teachers and ELLs that was distinctive of all sessions that the authors observed (eight sessions for all teams combined).

> *I asked the student I was working with questions about herself to get to know her, and she wouldn't even respond to my questions even though I tried to rephrase what I was saying to her to help her understand. […] Since it was online and you can't see her face that could be why she didn't respond at all.*

Only two out of nine SPED teachers found the first virtual meeting useful in terms of familiarizing with virtual worlds. A unique affordance, however, was identified as, "Being able to virtually meet with my ELL partner was nice, and I couldn't imagine doing the activity over the phone." The remaining comments were mostly negative. Respondents were disappointed because mostly they "just stood there", without having a purposeful role assigned. Due to the lack of interaction, they did not have the impression that the meeting had helped to improve the ELL partners' oral fluency. It was suggested that a tour would have encouraged interaction more effectively.

The third prompt inquired about features they liked about the interaction and their perceptions of the unique benefits of Second Life for this type of learning activity. While some respondents did not like anything, several respondents appreciated that there were no limitations by location or by physics. The potential to establish rapport in a virtual setting was pointed out too.

> *We actually had a few minutes at the end of the activity to explore the boathouses' kitchen and we both agreed that it (the kitchen) was very nice and we chuckled about that. It was nice being able to connect to my buddy about something we both appreciated.*

The virtual environment was described as offering language immersion to ELLs and as a way to introduce teachers to 3D technologies.

> *I realized the usefulness and the possibilities for offering an environment that may be less intimidating than face-to-face meeting for ELLs. I liked interacting exclusively with a group that had a facilitator who helped to orient the Cohort to the space, and who provided us with a shared set of expectations and goals. The unique benefits were that it not only provided ELLs with a means for immersion, it also gave new teachers access to technologies that we may not have engaged before.*

Several challenges were identified. Although some spaces offered separate sound parcels, they did not offer enough privacy:

> *You and your ELL partner had to go to a separate corner to work but other people would come and sit with you, this loud TV background noise kept interrupting the conversation, and other noises were distracting so it was hard to work with this student.*

Overall, the first virtual meeting was neither perceived as useful for the development of teaching skills nor as an

expansion of their virtual worlds skills and experience. The unique affordances of virtual worlds were perceived as being useful for language immersion (given adequate settings and time and room for private discussions), distance learners, and for learning activities that would benefit from the absence of physical boundaries. The two major challenges were the lack of a setting that would encourage discussion, the lack of effective private sound parcels, and the apparent technical glitches that consumed the major portion of the lessons. Due to these impediments, the SPED teachers' usability ratings of Second Life decreased dramatically after the first virtual meeting with their ELL partners, to the extent that the majority of SPED teachers were not looking forward to the second meeting.

F. SPED Teachers' Post-Survey

All 18 SPED teachers completed the post-survey after the second meeting. The first prompt asked, "Do you think that the meetings between you and your ELL partner(s) have helped them to enhance their oral proficiency? How would you have designed the meetings to help them improve their oral proficiency?" Only two participants stated that the meetings may have helped the ELLs to increase their oral fluency. Specific instructions and scenarios that would have guided the interactions and would have specified the SPED teachers' role would have been appreciated. Suggestions also addressed the lack of interaction and highlighted the need for a purposeful role of the SPED teachers.

> *An activity that might have been more successful would have been one that would have required not only speaking but actual interaction between the ELLs and the native speakers like a guessing game such as a version of 20 questions or Guess Who. These would give the ELLs a chance to practice speaking more than just two words. It would also give the native speakers a reason to be there and involved.*

Similar to the mid-reflections, it was criticized that the instructions were confusing. Several respondents stated that a face-to-face meeting would have been more effective and doubted the effectiveness of Second Life for these purposes.

Most SPED teachers acknowledged that Second Life has great potential because it allows for more interaction than other media, such as a video call, and because communicating through avatars appears to be less intimidating and to reduce anxiety levels. It provides anonymity for the ELL student and allows them to relax. Technology, however, was often seen as a barrier to learning. "I think that using Second Life as a language learning platform makes things harder than they need to be." The lack of social cues, such as facial expressions, was evident. It was unclear whether silence meant active listening, confusion, disinterest, or headphone issues. The design of the activities needs to be carefully thought out in order to allow interaction. It was acknowledged that a virtual world may be conducive to discussion, provided that activities are set up appropriately and there is ample support from the instructor and the facilitator(s). When asked if the two teaching sessions on EduNation had taken advantage of the potential of virtual worlds, most respondents reported that the tools, such as a game show set, were not used in a way to promote oral communication successfully and failed to allocate the SPED teachers a purposeful role.

The final prompt inquired about the unique skills that a teacher should have to teach in Second Life. A long list of unique characteristics and abilities was generated: Patience, kindness, understanding, non-judgment, technical expertise, strong communications skills, knowledgeable and experienced in the Second Life program, creativity in order to make materials enjoyable and accessible to many different learners, the ability to anticipate student needs without being able to read body language and facial expressions, the ability to diagnose a technical problem and troubleshoot, the ability to plan and implement a [virtual] lesson, the ability to specify and explain expectations and give clear directions in a calm manner, the ability to be clear and concise, the ability and willingness to organize activities in a way that everyone gets an opportunity to engage in an extensive conversation in a private chat area, the ability to stay calm in the face of technical glitches and not let the participants feel one's frustrations, think through the language demands of any given activity, and the ability to accommodate the needs of ELLs in a culturally sensitive way in order to allay their anxieties. A teacher in Second Life needs a back-up plan if technological errors take over the lesson.

Despite the numerous frustrations that these SPED teachers experienced, the post-survey reflected that, overall, the respondents found the experience interesting because it showed them practical examples of teaching in Second Life, although they thought that the unique affordances of Second Life were not fully taken advantage of. The potential of virtual worlds was recognized, provided that the design of the activities is well thought out and that technical glitches can be drastically minimized to enhance everyone's experience.

> *Fun experience. Frustrating at times, but awesome to see where technology can go in education. The thought of kids being able to do this on an ipad with more ease and perhaps a webcam feature with kids from across the planet is a very exciting concept!*

V. DISCUSSION AND CONCLUSIONS

The discussion of the results has been arranged around the three research questions. Five recommendations are made: anxiety-reducing lesson design, taking advantage of the full potential of virtual worlds, training the unique skills of a 3D teacher, enhanced voice communication, and collaborative design. These recommendations extend the guidelines suggested by Wang et al. [12].

1. What are the English language learners' and the special education teachers' perceptions of Second Life as a language-learning platform? Almost all ELLs perceived Second Life as a useful and interesting language-learning platform. A perception that was shared by many was that they had more opportunities to speak with native speakers than in real life. On the one hand, this statement is surprising, considering that all ELLs were actually studying at a university in the United States where the majority of students were English native speakers. On the other hand, it could be

an indicator of the difficulties that these students may have in engaging in conversations with native English speakers. ELLs have frequently indicated that communicating through a virtual world helped them to alleviate their anxiety, which is in agreement with Wang et al. [11]. Learning activities can be designed in a way that only the instructor knows the true identity of an avatar for assessment purposes.

2. What are the unique skills that a teacher should have to teach in Second Life? The SPED teachers provided a long list of qualities that they would like to see in a teacher teaching in Second Life. Many of these skills should not only apply to virtual worlds teachers, but should be present in all teachers. Examples include patience, kindness, and understanding. It is hypothesized, however, that a virtual teacher needs to have even stronger skills in these areas when teaching in a virtual environment where social cues and non-verbal gestures are mostly absent. To give directions, for example, an avatar cannot rely on supporting verbal directions by gestures. Especially the lack of smiling and eye contact makes it more challenging to establish rapport and to convey kindness and understanding. Among the most frequently mentioned skills of a virtual teacher were: the ability to give clear and concise directions, the ability to stay calm in the face of technical glitches, and the willingness and flexibility to resort to plan B if the lesson is not working out the way it was planned.

3. What types of problems associated with the EFL program in Second Life were identified? Although the ELLs' perception of the usability of Second Life for language learning was much more positive than that of the SPED teachers, both groups identified the same two challenges. First, the way that the lessons were set up failed to encourage interaction between the two groups. On the few occasions when they spoke with each other, the ELLs tended to give monosyllabic answers. It is recommended that language-learning activities in Second life be designed in a way that opportunities for interaction in private sound parcels are maximized. The visually stimulating and interactive environment in Second Life lends itself to extensive and engaging collaborative activities, such as scavenger hunts, in relatively authentic and contextualized settings. Oh and Nussli [15], for instance, reported about a lesson plan created by special education teachers that was designed around a collaborative scavenger hunt at the Star Trek Museum of Science in Second Life.

Technical issues, mainly related to voice communication in Second Life, were the second major challenge. Instead of the use of Second Life voice chat, it is recommended that Skype be used instead to accommodate both text and voice chat [16]. It is also recommended that an in-world facilitator support the instructor. Prior to the actual Second Life assignments, students will appreciate the opportunity to familiarize themselves with Second Life. Oh and Nussli [15], for instance, started an 11-Step Virtual Worlds Teacher Preparation Workshop with an hour-long class fieldtrip to five Second Life islands to ensure that students master the navigation skills required for the actual assignments.

Virtual worlds have provided broad access to native speaking communities and virtual spaces for learning and collaboration [12] and provide the potential to address the five components of the National Standards for Communication, Culture, Connections, Comparisons, and Communities [12]. Collaborative project design, however, can be challenging in virtual worlds. The findings of this study concur with Warburton and Pérez-García [17] who identified a set of guidelines that address factors fostering collaboration in 3D environments, such as running a social event before the main activity, ground rules for communication, making collaboration intrinsic to the tasks, guidance and regular briefing in order to scaffold gradually increasing levels of task complexity, video tutorials, and live mentoring/assistance.

Overall, despite several challenges, the participants in this study perceived Second Life as a useful, supplementary tool for instructors because it promotes contextualized language practice, provided that the lesson design allows for maximized interaction and that the participants receive support from the instructor and, if possible, a technical facilitator. The unique teaching skills were identified as well as a list of challenges experienced by both groups. The findings and guidelines will be relevant to other language instructors who plan to use Second Life for oral fluency enhancement. Virtual meetings between ELLs and English-native speakers in Second Life have the potential to offer an innovative, creative, and stimulating way to practice speaking English in contextualized settings, provided that the activities are framed by a pedagogical rationale that justifies the use of 3D technology. If ELLs are teamed up with native English speakers, specific roles should be assigned to the latter. But, even without the presence of native speakers, language learners can benefit from mutual interaction by practicing their language skills in content-rich virtual worlds [6]. Increased speaking opportunities with English-native speakers is likely to enhance ELLs' confidence and may encourage them to transfer the skills practiced in virtual worlds to the real world, specifically their university settings.

Limitations of this research are that all instruments relied on self-reporting and the teams only met twice for one hour each. Recommendations for future research include a more in-depth investigation of the effectiveness of virtual worlds on the oral fluency of ELLs and how instructors can design in-world activities effectively to take full advantage of unique affordances of virtual worlds.

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Web, Social Media and Online Communities for those Studying for Professions: Embraced or Tolerated?

Managing Information Online at The City Law School

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Abstract—**At a time of much debate on the subject of legal education within the UK, universities are having to look carefully at the content of their courses, their methods of delivery and ultimately whether this process is meaningfully shaping and future-proofing legal professionals or leaving them ill-prepared for practice. This paper seeks broadly to gain an understanding of the online tools law students use to support their studies and career progression. It focuses in on the use of social media tools like Facebook and Twitter, alongside the ways in which law students both seek and manage their information for learning. The online community aspect also formed a part of this research. Observations were made on the basis of two focus groups at The City Law School, City University London with students on academic law programmes. Students at City University have access to a custom-built online law portal: Lawbore, which acts as a one-stop shop, with community and social media elements as well as learning objects and multimedia guides. Lawbore has been in existence since 2002, and although constantly evolving it has never been formally evaluated; this research was prompted by needing to dig deeper into what students require from a resource such as this.**

Keywords-social media; online communities; portal; content generation; information retrieval; legal education

I. INTRODUCTION

Higher Education institutions who teach those aiming for a career in a profession – whether law, medicine or engineering, are facing challenging times. The cost of education is increasing; all undergraduates in the UK must now pay at least £9000 per year and they want to see tangible benefits from this investment. Of course, universities use many strategies to market their worth; glamorous estates, publicising successful alumni, cutting-edge research, prestigious academic staff and close links with employers amongst these. In addition, digital technology, including social media is increasingly being employed to attract and retain students.

This study focuses on the students of The City Law School and their use of the Internet and associated tools to support their learning of Law. The research, based on small focus groups, looked specifically at how students use technology independently, rather than in an organised way under the guidance of the Law School. However, the Law School's own portal for students, *Lawbore* [1], formed part of the discussions which comprise the findings in this paper. As a resource custom-built for our students, we were keen to gain some insight into which features the students felt had most impact on their learning. This would then help to inform future developments of the site and perhaps give some indication of which tools we should be promoting to our students.

The paper includes a methodology, detailing the focus groups and participants. We will go on to give a brief overview of both the legal education system in the UK and the use of technology within those Law Schools.

II. METHODOLOGY

Data has been collected informally (via unprompted student comments) as well as formally via focus groups and basic website statistics (within a university recognised ethical approval process). The focus groups were small - eleven students across two groups, and they included students from each of our academic law programmes. These are the three-year undergraduate degree (known as the 'LLB'), the two-year degree for graduate entry students (the 'GELLB') and the one-year law conversion course – the Graduate Diploma in Law (the 'GDL'). Different years of those courses were also represented so we had the views of first, second and third year undergraduates. Students volunteered to take part after receiving an all-school email invitation. Some element of bias could be evident as by definition more enthusiastic students would be more likely to put themselves forward. The composition of the groups was as follows:

Group 1:

A total of 7 students made up this group: four female and three male. Three GDL students, a second-year GELLB student and one student was present to represent each of the three years of the LLB.

Group 2:

A total of five students made up this group: four female and one male. Two first-year LLB students, one second year LLB student, one third year LLB student and a first-year GELLB student.

Both groups included international students – three in Group 1 and 2 in the second.

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The focus group sessions were very detailed and lasted between 90 minutes and 2 hours, with views flowing easily. They were filmed in their entirety in order to be able to pinpoint in the analysis which type of student was responsible for which comment. Questions posed covered two key areas: content generation tools like Facebook and Twitter and content consumption tools.

In terms of content generation, discussion ranged from social media tools like Facebook and Twitter to the perceptions and views on online communities. Questions focused on collaboration, portals and digital technologies; blogs and publisher resources. For consumption, we were keen to learn more about digital literacy in Law: the types of information students needed, how they researched, how they kept up to date, managed their findings and decided what was important.

As useful background, this paper will briefly introduce legal education in the UK as well as giving some insights into how technology has been used formally within Law Schools.

III. LEGAL EDUCATION IN THE UK

For students contemplating joining a profession, the commitment required both in terms of cost and duration is significant. For a law student, even once the academic element is completed, there is still the one-year professional element (£12,500 for solicitors and £16,000 for barristers).

Within Law, there is fierce competition for the 'apprentice' stage that follows; the training contract for solicitors and pupillage for barristers. Without this, a student career path stalls and can go no further. In 2013, there were 1700 students called to the Bar and fewer than 400 pupillages on offer [2].

Against this backdrop, law schools and universities in the UK are also undergoing a wholesale review: the *Legal Education and Training Review (LETR)* [3], which questions whether the academic stage of law remains fit-for-purpose.

The view of the employers – the law firms and the chambers - is that they have concerns about the quality of trainees: noting the lack of understanding about the commercial world, a canyon between their academic achievements and real-world business acumen. LETR articulates this: 'there are areas of cognitive expertise that are not adequately captured by conventional notions of the core. Key examples are professional ethics and values and 'commercial awareness' [4].

IV. TECHNOLOGY IN HIGHER EDUCATION AND LAW SCHOOLS

In terms of technology, universities are keen to exploit the tools available: in order to streamline their offerings, support students outside of core hours and enhance the learning experience. Technology is 'one of the most significant mechanisms currently transforming the learning process' [5]; at a basic level, most institutions have a virtual learning environment which would offer students a place to find materials for their courses (handbooks, reading lists) and the facility to submit assessments. The more adventurous uses may facilitate the use of more interactive options - wikis, reflective blogs, peer feedback and quizzes in order to engage their students more actively.

With so much discussion around whether legal education is fit for purpose: what do law students really want from their institution in terms of support online? What tools do they use to assist them? More importantly perhaps, research is required around how students work to see what technological solutions are most useful.

Education for the professions has in the past been largely delivered via lectures and tutorials, but the rise in multimedia has altered the landscape. In Medicine, video how-tos are now commonplace – there have been many apps developed to assist medical students with directories of clinical information and virtual anatomy tours such as *3D Brain, Radiology 2.0* and *Muscle and Bone Anatomy 3D*. This is also becoming more familiar within Law, although progress is much slower. Some years ago, Paul Maharg pioneered the use of simulations by designing a virtual town (Ardcalloch) where his Strathclyde students could become solicitors at virtual law firms acting for virtual clients [6]. More recently, The University of Law took the decision that all its lectures were online only, saving its lecturers for the more interactive tutorials, now known as the flipped classroom model.

At City Law School we have developed a custom-built portal to support our students (est. 2000). The *Lawbore* and *Learnmore* [7] websites run alongside and complement Moodle, the Virtual Learning Environment (VLE). *Learnmore* offers law students nationwide open access to legal skills materials, integrating video clips and guidance materials in which students and alumni feature.

Lawbore offers a gateway to supporting resources for different modules in Law, a hub for accessing and understanding e-resources, a careers blog, *Learnmore* (the skills wiki mentioned above) and many community elements; news, events calendar, Twitter integration, legal feeds and small ads. The blog and *Learnmore* invite contributions from students, which could be articles about a pro bono experience, advice on how to come across well in interview, tips on networking, an interview with a prominent lawyer or a write-up of an event. The website has received much recognition from both the Higher Education and Law communities [8], and students from all over the UK value it. The website receives in excess of 2000 visitors a day and its popularity is best summed up by this email received from a student on returning from the National Law Student Forum in 2012: "*...when the students knew I was representing City University they couldn't stop talking about Lawbore. Words can't describe how happy I was to see students outside our university talk about it and use it. I couldn't but explain to you how thankful I am of you, and all that effort we see you put-in, pays off"*. Students use it as

a starting point for research; a support network and a place to check-in and find out what's going on within the Law School or in the wider legal world. We hope that it adds value to their studies, but had only ad hoc unprompted feedback as a basis for this.

V. LAW STUDENTS AND CONTENT GENERATION TOOLS

Lawbore isn't interactive in the sense that students can create content instantaneously, but it does encourage students to get involved. The blog invites contributions from students and they submit content from event reviews to accounts of work experience. *Lawbore* has a Twitter account which features on the hub part of the site; students using Twitter do frequently ask questions and advice as well as mention content featured here:

@lawbore: *Studying Equity & Trusts this yr? Check out free issue of Trusts & Trustees jnl for inspiration! Ow.ly/oWltg (via roxanneselby)*

@D_Taylr: *@lawbore Some great articles in there relevant to my dissertation! Thanks Emily, hope all's well!*

Learnmore is loosely built using a wiki structure and also features content which the Law School and students have collaborated on. Examples include guides co-written with students, video clips starring students demonstrating practical legal skills like mooting and articles from our alumni offering tips based on their experience.

A. Social Media

Recent years have seen many success stories around the use of social media in teaching, but we were more interested by how students used such tools self-sufficiently. Selwyn [9] notes how Facebook's role seems to be more about social support – a place to go to sound off about your study, your lecturers and how badly an essay is going, than as a place for learning collaboration. It is seen as a place to seek clarification when official channels are not clear or unavailable. The perception is that most students will use social media regularly, but it is not as clear how it is used for study-related purposes. In Hrastinski and Aghaee's [10] 2012 study, all but one of the students used social media daily but "they perceive that their use is not related with their studies".

The professions in general have a mixed relationship with social media, balancing the benefits (networking, current awareness, promotion) with the risks (professional integrity compromised). Law websites, like the gossipy *Legal Cheek* [11] thrive on exposing lawyers who have used social networking sites ill advisedly. Professional standards are an essential part of ensuring public trust in a profession and students of that discipline are expected to abide by these also. Social media has meant that the world in which these standards apply has extended vastly. Codes of practice will normally specify that members will maintain professional integrity at all times, which would encompass guidance on confidentiality and appropriate boundaries, e.g. between doctor-patient or lawyer-client. Mansfield et al. [12] note that in the medical world students are not expected to develop quite the same professional ethics as doctors. This is despite 60% of deans of US medical schools reporting unprofessional postings from students online [13], however some of these incidences did result in official warnings and dismissal.

> 'Experiences that were once ephemeral in nature are now being captured and archived by social media technologies, allowing such experiences to be re-examined in the future, when they may be seen in a different light'. This has the potential to not only erode the public's trust in the medical profession, but also to mar the professional reputation of individuals' [14].

UK Professional bodies like the British Medical Association [15], Chartered Society of Physiotherapy [16] and The Law Society [17] have all compiled their own guidance and toolkits on using social media. The Web is alive with tales of social media bloopers, particularly in the legal world – but this is no new thing. Employees sending out emails to their whole firm rather than one individual, boasting of the previous night's exploits or detailing their views of the company, have been commonplace for many years:

"I'm busy doing jack shit. Went to a nice 2hr sushi lunch today at Sushi Zen. Nice place. Spent the rest of the day typing e-mails and bullshitting with people." [18]

Pitfalls aside, increase in users of social media is steep. Research from 2012 showed that 47% of staff from the Top 50 law firms had profiles on LinkedIn, nearly double the number than in 2010 [19]. Similarly, many lawyers are now blogging; many with the intention of making law more accessible to the general public, others to raise their profiles. David Allen Green, Head of Media at law firm Preiskel & Co has seen his profile rocket – becoming perhaps the leading UK lawyer on social media after championing the underdog by taking on the *R v Paul Chambers* case (the 'Twitter Joke Trial') and writing about the law on his blog, *Jack of Kent* [20]. Green now writes for the Financial Times in addition to his media practice, and has a significant Twitter follower count. Law students are also blogging, although some Law Schools in the US are warning students off such mediums [21].

With all this in mind, and no ready data, it was desirable to investigate via the focus groups what social media tools law students are making use of. What emerged very strongly from these groups is that these students were consumers rather than creators "*I don't tweet but I like to use it to search for information*"; but social media was far from being an essential tool for them, even as users. The undergraduates showed more enthusiasm for Twitter and Facebook than the postgraduates.

Facebook proved unpopular (*"too much of a procrastination tool"*); and those who were members mainly limited use to the purely social. Sets of barrister's

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chambers who used Facebook were flagged up by one student as being useful for *"getting a feel for the set which doesn't come across on their website as they are trying to sell themselves to potential clients"*. Likewise, law firms who used their Facebook pages for more interactive dynamic content were praised; particularly those who shared blogs from their trainees.

Students seem protective of their own space on social media; Jones et al. (2010) speak of the divide between 'life' and 'studying' [22] and how students don't want the two to crossover via social media, and the focus groups backed this up. There was some discussion amongst undergraduates about a programme director who had tried to join their Facebook group but who had been blocked.

Twitter fared a little better, but with only three enthusiastic users. However, students listening to the individual speak about the benefits in Group One were really interested. Comments included *"if you have questions, best way to get answers"* and *"I've found Twitter really helpful. Just for a quick snapshot I can check it daily. Obviously you have to go further for a little more depth. Depending on who you follow it's been really useful"*.

Students liked the Lawbore Twitter feed; "*really important that it's there…as our librarian it makes you a bit more human. Someone you could go and talk to*".

They liked it when academic staff tweeted too (although this was not a common occurrence), with lecturers recommending others to follow and blog posts of interest: "*they give you a look at what your professor's opinion is on the latest news, they would respond to articles – interesting to see where they're looking for their information*".

Surprisingly, few students noted blogs as a worthwhile academic source, tending to stick to print books and legal databases to find their commentary within academic journals. One student noted: "*I used blogs when studying for exams especially for constitutional law – much debate over topics – constantly changing. In exams where you know they will be heavily based on essays. Nice to get different opinions. All written by professors or scholars – not just joe schmo writing about…"* Many highly regarded law professors are now blogging, so this is another very useful source for students [23].

The comment above shows that, despite long-standing perceptions about students not being able to judge the quality of sources, these students seemed very canny – discussing when they would use google as a search engine or look something up in Wikipedia [24]: *"First port of call is a Wikipedia article to get a broad overview. If I need more information I'll go to Westlaw* [25] *or Lexis* [26]*"*.

One student mentioned the use of podcasts online where they had caught up with an episode of the Radio 4 Law in Action programme and one of the subjects covered had come up in a scholarship interview. The students were all very complimentary about the video resources available in *Learnmore*, particularly the mooting section.

B. Online Communities

Lawbore plays an important role in creating a 'community feel' for the law school; inviting contributions from users and providing all-round information relevant to the students. Students really liked that it links up academics, current students and alumni: *"really liked how in the piece about national essay competitions you linked to the work of City students who had won it in previous years – this bolstered my confidence to enter"*.

Law students are often seen as very competitive; *The Princeton Review* in the US surveys students and ranks law schools. Competitiveness is part of this, with students asked about the number of hours they sleep per night, hours spent studying, how many hours they think their peers are studying and competitiveness [27].

In the UK, we were keen to see whether this was true in relation to their study and career progression and the groups were asked how readily they shared information with their peers. Surprisingly, the postgraduate students were far more open with their work; they used Dropbox to set up shared folders in their tutorial groups for people to add their 70%+ essays and revision notes. One GDL student noted: *"the only way you are going to get through the GDL is by making friends. No way you're going to do all the work and know everything…we've all done a degree before we're not so competitive about it…we just need to get the commendation as a minimum and you'll be ok. Didn't really matter if we're going to share our notes. You didn't really feel like it was going to have much impact on the rest of your life"*. There was a clear imperative to collaborate just to get the work done.

This wasn't always the case for the undergraduates – several students were against sharing any information "*if it's for coursework and you found an article that was brilliant– I'm sorry I don't mean it in a horrible way but I'm selfish like that. My coursework is being compared to someone else's. If we all put the same thing we're not going to get a good grade"* (LLB2). A third year LLB student mentioned that amongst her small group of friends they would share assignments and work out together where they may have been able to improve.

This echo's Selwyn's findings [28] (2009, p.167) in whose study "it was noticeable that students were generally unwilling to offer extensive assistance to each other".

When securing paid employment is so tough, we were curious whether their views on sharing information altered when it concerned opportunities. This was mixed, with some stating that they alerted each other to application deadlines and even recommended their friends to firms or chambers they'd had work experience at. Others hadn't been as lucky: *"…sometimes competitiveness will get in the way of that - I had a couple of times where people I was reasonably good friends with were like 'oh the deadline for that just passed did you apply for that?' They hadn't applied either but had engineered it so that I wouldn't apply. You*

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could just tell. I think competitiveness does come into it, word of mouth not always effective."

VI. LAW STUDENTS AND CONSUMPTION

A. Seeking Information

Locating information is an essential part of life at any higher education institution; students need to learn new tools (databases) and also gain an understanding of the required sources, as well as how to distinguish between authoritative and untrustworthy information. Taking our law and medicine disciplines again; obviously using the wrong information goes far further than just failing an essay – using a case or medical procedure that is out of date can have significant consequences. Ethics and accountability are integral to these courses from Day One.

What kinds of information were our law students looking for?

- Legal materials for study (cases, journal articles, legislation, practitioner commentary)
- Information about future employers – law firms, barrister's chambers
- Information about work experience – pro bono, internships, mini pupillages, vacation schemes
- Research materials to prepare for interviews/applications
- Upcoming events

How they found these types of materials varied hugely; they understood the need to be up to date and used strategies from the basic (*"checked noticeboards outside careers centre"*) to the academic ("*I've been using the Student Law Review recently as it gives roundups of all the latest case law in different practice areas*") and did use technological solutions available (*"I get the Guardian Law newspaper bundle into my email. I'm generally quite lazy so it's good if something comes to me"*. They liked the various legal news feeds on Lawbore.

Interestingly, this group was far more convinced by the power of word of mouth than any technology solutions. Does this tie into the perceived 'exclusivity' of Law – a world where only contacts count? They sought information from their peers "*I spoke with students from year above in terms of what courses I might want to do in year 3*" and from practising lawyers where possible. Finding work experience was definitely an area they felt this was particularly true; "*Word of mouth has probably been responsible for 75-80% of anything I've ever done*". They saw no shortcuts to this kind of information but strongly believed in networking but not that of the virtual kind. This again resonates with Hrastinski whose students felt social media lacked efficiency when compared with face-to-face contact [29].

Law apps in the UK are few and far between – in discussion, just one student mentioned a legal dictionary and the others more general scheduling and flashcard tools for exam revision purposes.

B. Organisation

As mentioned already, students used file-hosting services like Dropbox [30] or Google Drive [31] to store and share essays, revision notes and useful legal materials they discovered in database searches. They founds this useful because of portability: being able to access from any device. Many students however, still printed out any useful sources they found.

C. Print v Online

Law more than other subjects is reliant upon students having expertise in both types of materials; e-books had a mixed reception *"...with an e-book I might miss something because I can't flick through it like a book*". Searching for specific keywords quickly within a big text was seen as a benefit however. One GDL student tried to explain using print and online was a physical representation of what law students are doing mentally: *"Take lots of information and form it into a cohesive argument"*.

D. Authority

Asking whether they used Google resulted in a resounding 'yes'. Students noted that they'd found lots of useful information, and found it especially helpful if searching for something really simple or to find "*a couple of different explanations so you can pick and choose*". They showed awareness of its limitations however: "*I wouldn't use it in an academic essay*" and "*You have to be careful. Like if it's reputable or not*". Undergraduates at City receive guidance on this in compulsory legal research classes in Year One.

They had picked up that certain authors were more influential than others "*if you see Martin Dixon you know it's authoritative*", detailing the various methods used to find materials "*looking at footnotes in practitioner texts – might be obscure but useful*". They also set themselves high standards, asking themselves whether they'd be happy to use a reference in Court before using it in an essay.

VII. IMPLICATIONS FOR TEACHING AND LEARNING IN THE PROFESSIONS

Nationally, the *Legal Education and Training Review* pushed for greater cohesion between the profession and academia – more flexible (and affordable) routes to entry and for an academic stage with an increased practice-base.

Those in the legal profession are using social media and other digital tools extensively, but on the basis of this limited study it would seem a long way off before law students embrace social media tools and online communities in the same way. They have a good understanding of sources and traditional tools but their use of the collaborative tools is more limited. This may go some way to explaining why the Lawbore portal has achieved some success – as a bridge between these two worlds – allowing users to keep up to date with what's going on at City and the wider legal world but not demanding interaction.

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The intensity of the Law courses doesn't leave students with a great deal of time to experiment with new tools, but is does seem that there is a case to be made for academics and other university staff to promote the use of such tools more extensively. The students knew about the various tools available, and the advantages they offered but just hadn't integrated them into their research practice. As we saw with the Twitter example, when they saw their lecturers using the tools they were inspired to do so too.

Universities need to take steps to encourage student use of the tools that can make their lives more efficient; in legal practice, steps forward in technology have meant that the ways lawyers work have changed. Professor Richard Susskind, IT Adviser to the Lord Chief Justice of England and Wales called for law schools to start preparing students to be 'Tomorrow's Lawyers' (also the title of his latest book) and equipping them with the skills to carry out these jobs of the future. Included in his list are roles such as: enhanced practitioner, legal knowledge engineer, legal technologist, legal hybrid, legal process analyst, legal project manager, online dispute resolution practitioner, legal management consultant and legal risk manager [32].

Exciting worldwide initiatives are underway which link law and technology – *Law Without Walls* [33] is an innovative legal and commercial education project started at the University of Miami. Students from 26 universities around the world team up and develop business plans to tackle real-world challenges within legal education and practice, whilst being mentored by academics, lawyers and entrepreneurs. *LWOW X* [34], an all-virtual pilot version was launched, aimed at spreading the opportunities more widely.

Open Law Lab [35] seeks to link creativity and Law – with creator Margaret Hagan working on several themes in which she envisages interdisciplinary teams collaborating. Her ideas around visual law link in with the work done on *Learnmore* via illustrations, video and talking slideshows – helping bring text-heavy legal resources alive.

VIII. CONCLUSION AND FUTURE WORK

This is a small-scale qualitative study, which has attempted to explore some of the values and attitudes that students bring to their use of digital technologies in pursuit of their law studies. A wider survey could include both qualitative and quantitative data collection.

However, the study does offer key observations around the somewhat 'take it or leave it' approach to social media displayed by the students. This was unexpected, as was the real disparity around sharing of information between undergraduates and postgraduates. It was encouraging to see how quality of information is important to them and forms a part of the decision-making process in deciding which source to use within their studies. Similarly reassuring was the professional focus that the participants had throughout, with tools assessed not just in terms of their value for learning, but also with an eye on their long-term usefulness for their future career path.

There is some hint that Lawbore seems to offer a halfway house between the institutional VLE, Moodle, and the students' personal use of social media tools. This bifurcation could perhaps be a result of tensions around 'enforced' institutional participation in VLEs.

We intend to report further on this research, the preliminary results of which are discussed here. Future evaluations will be on a more ambitious scale and will seek to bring further clarity to the information gathering habits and social media use of law students. We will also seek to extend the reach of the research by doing some comparison work with trainee solicitors and pupil barristers, and place this within the wider sphere of other professions.

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Improving e-Learning Environments for Pen and Multi-touch Based Interaction

A study case on blog tools and mobile devices

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***Abstract*— e-Learning environments are applications that use the Web infra-structure to support teaching and learning activities; they are designed to have good usability using a desktop computer with keyboard, mouse and high resolution medium-size display. Devices equipped with pen and touch sensitive screen have enough computational power to render Web pages and allow users to navigate through the e-learning environments. But, pen-based or touch sensitive devices have a different input style; decreasing the usability of e-learning environments due the interaction modality change. To work on mobile contexts, e-learning environments must be improved to consider the interaction through pen and touch. In a previous work, we presented the InkBlog, a blog tool that receives input data from pen allowing users to handwrite posts. In this work, we present an extension of InkBlog to receive input from multi-touch screens. We described the changes over the InkBlog architecture and implemented components to treat data generated by pen and touch.**

Keywords-Human-Computer Interaction; Electronic Learning Environment; Mobile Devices; Interaction Styles.

I. INTRODUCTION

e-Learning environments, such as Moodle [1], SAKAI [2], TelEduc [3], Ae [4], are applications that use the Web infra-structure to support teaching and learning activities. The e-Learning environments are designed to support a variety of users and learning contexts, but they are designed to conventional computers, usually equipped with keyboard and mouse as input and a medium screen and speakers as output; a limited set of interaction styles for nowadays devices. These modalities, and the technology that support them, shape the teaching and learning activities done in the e-Learning environments; they focus on reading and writing skills.

One example of tools available at e-learning environments is Weblog, a communication and collaborative tool that aims to promote the sharing of messages among participants through an area named blog. Users can publish texts, images, audio, videos and links, sharing their opinions, in posts typically displayed in reverse chronological order (the most recent post appears first) and allowing visitors to leave comments. In this way, blogging can be seen as a form of social networking.

Mobile devices, such as smartphones and tablets, are becoming increasingly popular; most of them have touch screen displays, Internet access and enough computing power to process Web pages. So, it is possible to access blog tools, read the messages, post new messages and write comments through mobile devices. But, it is important to consider that these tools (and so their Web pages) are developed to be accessed by desktop computers equipped with keyboard, mouse and a medium size display; in your previous work we described that when a user interface designed for a set of interaction styles is accessed by a different set of interaction styles the users face interaction problems [5]. Another problem is that it is not possible to take advantage of the interaction style features; for example, in a desktop computer, users use the keyboard to typing the post text. In a pen-based computer without handwrite recognition, users need to type each letter pressing the pen in the respective key in a virtual keyboard. This way of writing texts takes a lot of time, make boring the writing task and do not take the mainly pen purpose: handwriting and do sketches easily. In the case of touch sensitive screen, the user can touch in the virtual keyboard to write the post, but it is not possible to do sketches.

So, we believe that blog tools and e-learning environments need to be improved to be easier to use in some devices and some contexts, e.g., areas which need sketches or drawing such Mathematics. In our previous work [6], we developed the InkBlog tool to easily write handwrite or sketched posts in pen-based devices by adding features to manipulate electronic ink into a blog tool from Ae, an e-Learning environment. But, the InkBlog have some limitations: display handwriting posts correctly in smartphones, but it is not possible to sketch post. In this work, we add some features to improve the InkBlog to allow users to write messages in many devices: desktop computers, smartphones and tablets.

Section II presents a literature review about electronic ink technology and e-Learning environments, focusing on Weblog tool. Section III presents the InkBlog, describing how the technologies are employed to allow users handwriting posts and comments using pen-based devices. In Section IV, we present the modifications done in InkBlog to allow users to interact using multiple fingers. The last section presents the conclusion and future work.

II. E-LEARNING ENVIRONMENTS AND INTERACTION STYLES

The World Wide Web has changed since its invention from a static to a highly dynamic media in the recent years; so, the term “Web 2.0” was coined in 1999 to describe the

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web sites that use technology beyond the static pages and its uses for collaborative, user-centric content production and interactive content access [7]. Safran, Helic and Gütl [8] describe that in literature the marks of Web 2.0 include: (i) social phenomena, such as the Web for participation, (ii) technology for significant change in web usage, and (iii) design guidelines for loosely coupled services. The Web 2.0 allows users to interact and collaborate with each other in social networking sites, weblogs, podcasts, wikis, video sharing sites and other sort of tools.

One kind of Web applications that have some Web 2.0 features is e-Learning environments, as Moodle [1], SAKAI [2] and Ae [3]. They are applications with tools to support teaching and learning activities though the Web. Tools in these environments allow users to create content, communicate with other users and manage the virtual space. Tools like chat, forums, portfolios, repositories are widely used, and tools that explore the audio and video resource to user communication, such as instant messenger and video-conferences, are becoming common among the environments.

HyperText Markup Language (HTML) is used for any web application to describe the page interface and its content. Usually, in web applications that users post text, there is a rich text editor to allow users write formatted text without HTML skills. In desktop computers, the users use the keyboard to typewrite the letters, and use the mouse to select format functionalities (some of them have shortcuts to be triggered by the keyboard). Since the rich text editors have a direct manipulation interface similar as text editor applications, it is easy to be used in desktop computers equipped with mouse and keyboard.

The HTML have some improvement defined in the last version, the HTML5, related with support multimedia, keep it easily readable by humans and consistently understood by computers and devices [9]. HTML5 adds the new <video>, <audio> and <canvas> tag elements, as well as the integration of Scalable Vector Graphics (SVG, a vector image format for two-dimensional graphics based on eXtended Markup Language - XML) content and Mathematical Markup Language (MathML, a XML based-format to describing mathematical notations) to integrate mathematical formulae into Web pages. These features are designed to easily include and handle multimedia and graphical content on the web without having proprietary plugins and Application Programming Interface (APIs) installed.

The <canvas> tag allows for dynamic, scriptable rendering of 2D shapes and bitmap images; it is a drawable region defined in HTML code with height and width attributes. JavaScript code may access the area through a full set of drawing functions similar to those of other common 2D APIs, thus allowing for dynamically generated graphics.

Another evolution in HTML is standardizing how the browser must handle events from touch and pointer inputs [10]. The W3C Group specified that “The Touch Events specification defines a set of low-level events that represent one or more points of contact with a touch-sensitive surface, and changes of those points with respect to the surface and any DOM (Document Object Model) elements displayed upon it (e.g., for touch screens) or associated with it (e.g., for drawing tablets without displays)”. This specification was done thinking in devices equipped with stylus such as tablet and define event types for: (i) when a user touch the surface (touchstart), (ii) when a user remove a touch point from the surface (touchende), (iii) when a user moves a touch point along the surface (touchmove), (iv) to indicate a touch point has been disrupted (touchcancel). Having different event types for input data generated by each modality gives flexibility for the developers define the actions to be trigger for each modality.

W3C defines XML formats for non-primitive data to allow exchange of a wide variety of data on the Web and elsewhere; one example is Ink Markup Language (InkML) [11]. The InkML provides a common format for exchange ink data between components such as handwriting and gesture recognizers, signature verifiers, sketches, music and other notational languages in applications. The InkML serves as data format for represent ink gathered by an electronic pen or stylus. It is possible to find some uses of InkML, such in Microsoft Word 2010 support electronic ink in text review and the InkML JavaScript Library [12], that offers some functions to allows InkML digital ink to be referenced within Web pages and rendered directly into the HTML5 <canvas> tag.

Considering the technology breakthrough that HTML5 proposes, most of the web sites use HTML5 to impress users through content exhibition; few developers take care about the user input interaction styles, so they develop web pages for users with keyboard and mouse in desktop computers and not appropriate for touch devices. But, this scenario is changing with the smartphone and tablet popularization: the web designers need to think about the other interaction styles, such as touchscreen and pen-sensitive devices.

In pen-based devices when the user moves the pen in the screen, the pen trace should result in electronic ink that must be treated by the application to be rendered and stored. But, desktop applications, that running in the Tablet PCs, do not treat electronic ink, so it is necessary to incorporate special applications to treat the electronic ink to have benefices of the pen interaction style. This is the case of Classroom Presenter [13] and others pen-based software. In our previous work [14] we studied three applications (Professional Adobe Acrobat, Windows Journal and Jarnal) to do classes annotations or writing manuscript texts in student activities using a Tablet PC, describing some identified usability problems. We conclude that desktop applications that do not manipulate the electronic ink loose the Tablet PC potential because the pen is used just as a pointer device. This is valid for web applications.

In our previous work, trying to develop web applications that do a better use of pen interaction, we developed the InkBlog for Ae environment, described in the next Section. We chose a blog tool because edublogs, blogs with educational purpose, archiving and supporting student and teacher learning by facilitating reflection, questioning by self and others, collaboration [15] and by providing contexts for engaging in higher-order thinking. Ray [15] cites four ways

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to incorporate blogs into the classroom, including: (i) using them to communicate information to students and parents, (ii) to provide instructional resources and useful links, (iii) to allow students the opportunity to collaborate with one another on various projects without being in the classroom itself, and (iv) to showcase student work and projects, like poetry and photographs of project work. Another motivation is that users can share draws and images, and the stylus allows users to draw in the device.

III. THE AE ENVIRONMENT AND INKBLOG TOOL

The TIDIA-Ae Project (TIDIA-Ae is the acronym for "Tecnologia da Informação para o Desenvolvimento da Internet Avançada – Aprendizado Eletrônico", in English "Information Technology for Development of Advanced Internet – Electronic Learning") was initiated by FAPESP (the State of São Paulo Research Foundation) with the main goal of developing an e-Learning environment that can explore the potential of Advanced Internet and can provide support to different educational context needs: the Ae environment. Several tools are developed for Ae environment such as Portfolio, Mail, Discussion Forum, Chat and Weblog.

In e-Learning environments, each course participant (student or teacher) owns a blog, where she can post or exclude messages sharing texts, video or audio messages with other participants. Each participant may access other course participants' blogs, comment posted messages by the owner of the blog.

To publish a message in the Ae´s Weblog, the participant clicks in the link "Compose a new post" in her blog page. A new page within a form to be filled will be displayed. After filling up the form, the user clicks on the "Confirm" button and the system will save the new post and redirect the user to the user´s blog page displaying the new message at the top.

The Weblog uses a rich text editor to allow users to easily write formatted text without having knowledge of HTML. For desktop computers the rich text editor works well, the user type the text in the keyboard and use the mouse or shortcuts to trigger format features. But, in the case of pen-based tablets the usability decreases: the user needs to typewrite each letter pressing the pen over the respective key in a virtual keyboard. It is not possible to handwriting or sketching, actions done with a pen and paper.

Ae´s Weblog tool was designed in a design-evaluation process. The first step to create the Weblog´s user interface was to develop a high-fidelity prototype considering the user will interact in a desktop computer equipped with mouse, keyboard and a high-resolution medium size display. This user interface was evaluated and some modifications were done before codifing phase. A usability test was done with the first implement version, and some modifications (e.g., removing some functionallities and changing some labels) were recommended. The final version is presented in Figure 1.

In our previous work, we presented the InkBlog [6] (Fig. 1). It was created to make easier to handwrite posts and comments using a stylus in pen-based devices. The approach to develop the InkBlog was to increase the Weblog tool with components to generate and manipulate the electronic ink in the user interface, representing the electronic ink in InkML format; before a usability test was done to identify problems when user interacts with pen. Changes in the Weblog´s architecture (Fig. 2) and user interface (Fig. 3) were done to support input data from stylus. In the architecture we added a component to receive data from pen, the InkController component, and a component to renderer this data as electronic ink, the InkRenderer component. Both

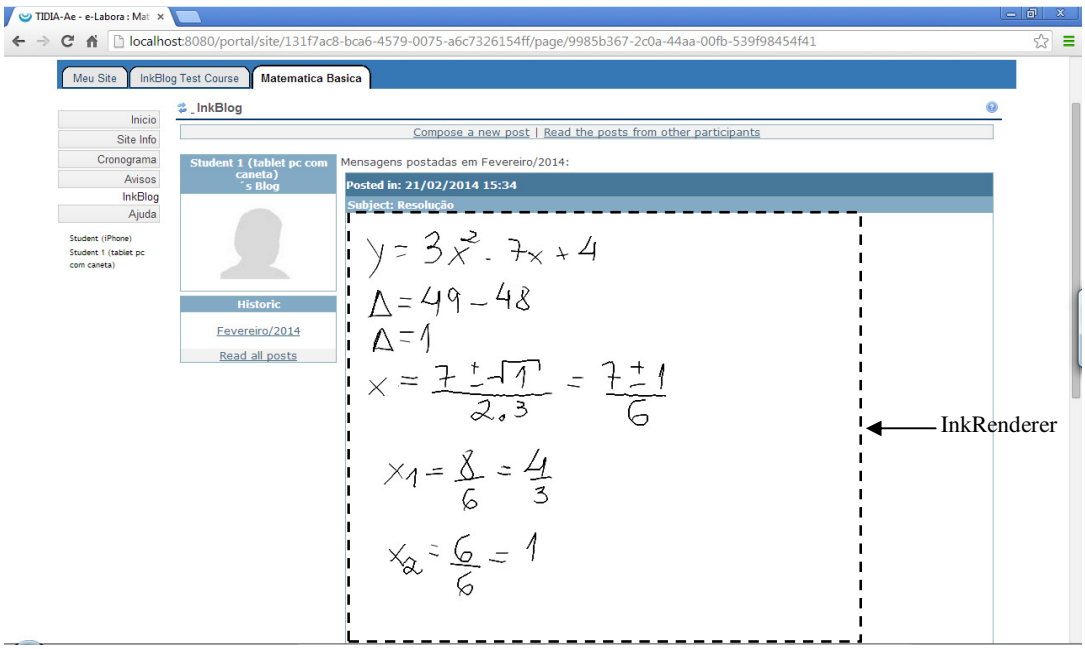

Figure 1. Using InkBlog to share a resolution about finding root for quadratic equation rendered by Google Chrome browser in a Tablet PC.

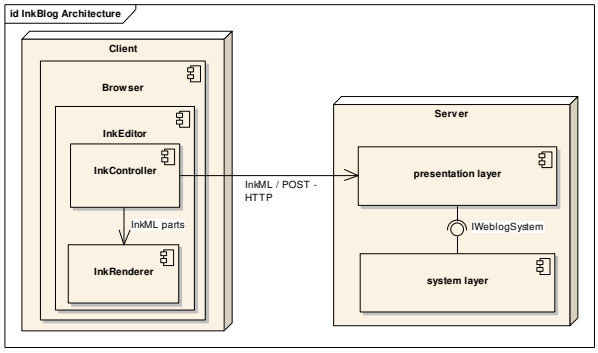

Figure 2. InkBlog components to treat input data from pen.

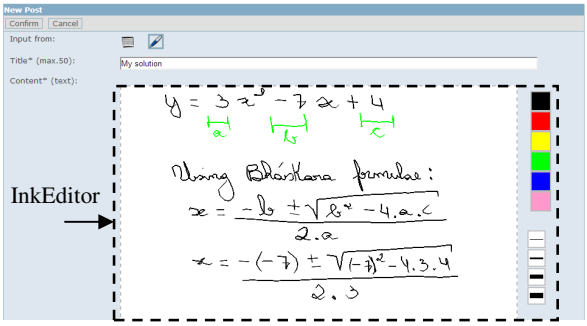

Figure 3. Using InkBlog to handwrite a post using a stylus.

components, InkController and InkRenderer, compose the InkEditor: a handwritten text editor for web pages that render the electronic ink and receive the input data generated by stylus.

The pen input data is received by the InkController, which transforms each point of the trace into coordinate points following InkML format. The user can choose the trace´s color and the width selecting the buttons options in the right side (Fig. 3). When the user points out and presses the pen into a color or width button, the next traces will have the brush attributes set to look like the selected options.

The InkRenderer, the other InkEditor component, draws the traces of a handwritten post in the user screen (Fig. 1). The InkRenderer´s code, the electronic ink data in InkML format and the HTML page are sent to the client over the HTTP protocol (Fig. 2) to display the page with posts. After all the data and code arrived in the client, the InkRenderer reads the InkML data resident inner the tag canvas, and draws the electronic ink for each trace, taking into account the ink formatting. The InkRenderer was developed using the InkML JavaScript Library.

To post a new message, the user can choose the input hardware (keyboard or pen) selecting the icon on “input from:” field, to type the text using a keyboard or to handwrite a post with a stylus (Fig. 3). When the user chooses the pen, she will write a handwriting post, the browser will hidden the text editor and show the InkEditor, where the user will use the stylus to handwrite. When the user touches the InkEditor within the pen and draws a trace, the InkController will listen to the user actions, getting the dots that compose the trace. Each dot is recorded and a line connecting the preceding point to the new point is drawn until the user releases the pen. After the pen is released, the InkController will generate the InkML´s trace node for the new trace. The user can draw as many traces she wants, all them will be stored and will compose the InkML data. When finished handwriting the post, the user will click in the Confirm button and the generated InkML data will be sent to the server to be stored.

Some changes were needed in the Web application to distinguish textual content from typewriting content and to show the correct editor in the post view. The changes are done in the presentation layer; the other layers have not been changed.

The client device needs to have a compatible HTML5 browser to run the InkEditor. The InkEditor uses InkML to represent the handwriting data and the Canvas HTML attribute to draw the traces in the screen.

It is also possible to handwrite comments and post them: the process is similar to the described process above.

IV. IMPROVING BLOG TOOL FOR PEN AND TOUCH INTERACTION

To support touch interaction, we developed a new version of the InkBlog, extending it with features to manipulate data from touchscreens. To include touch interaction, we adopted the same evolutionary approach as when we included pen interaction: usability test with user interaction with pen (two devices were considered, a smartphone and a tablet) and modifications of the user interface, following usability tests.

Multi-touch in web applications is more common on games; Johnson [16] presents a tutorial to include features of multi-touch in web applications. Analyzing the InkBlog code, we modified the InkController code to support touch devices including the handling of touch events defined by W3C. The first modification was handling the touchstart, touchmove and touchend event types. Since we wanted the users draw with their fingers in touch sensitive devices, these events types call functions to start a line, to compose the line, and to stop to draw a line, respectively. This modification allows users to interact with one finger per time.

To allow multi-touch, it was necessary to use a <inkml:trace> to store the data from each finger in a array. The browser send to the function that will handle the user interaction an event object with the *changedTouches* attribute, a collection with data from one or more modified touch points. To identify finger´s move it is possible to use the event´s *identifier* attribute; this value was used as index in the array of <inkml:trace> to put the data in the correct line.

To avoid the browser to scroll the page when the user moves the fingers on the screen, it was called the event´s functions *preventManipulation()* and *preventDefault()*.

To test the new version of InkBlog we used a Tablet PC, a tablet and two smartphones. The Tablet PC is a HP TouchSmart TX2-1040br, 2.2 GHz dual-core processor with 3 GB RAM and a 12” multi-touch screen with Windows Vista operating system and with Windows 8 operating system. This model has the design similar to HP laptops but

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it is equipped with the described hardware for Tablet PC, for our purposes, a pen sensitive and touch sensitive screen. Google Chrome browser version 31.0.1650.57m was used to navigate through the e-learning environment. So, the used Tablet PC has pen and multi-touch modalities.

The tablet used in the session tests is a Brazilian Positivo Ypy AB10EC, 1.0 GHz ARM Cortex A9 processor with 1 GB RAM and a 10" multi-touch screen 800 x480 pixels of resolution with Android version 4.1.1 operating system. In the iPhone, the used browser was the Google Chrome 31.0.1650.59.

The smartphones used in the session tests are an iPhone 3GS and a Motorola Milestone. The iPhone 3GS has a 833 MHz Samsung S5L8920 ARM Cortex-A8 processor with 256 MB RAM and a 3.5" multi-touch screen 480 x320 pixels of resolution and iOS version 6.1.3 as operating system. In the iPhone, the used browser was the Safari. The Motorola Milestone has a 600 MHz Cortex-A8 processor with 256 MB RAM and a 3.7" multi-touch display 854 x 480 pixels of resolution and Android version 4.0.3 as operation system. To browse in the Web application, the Android stock Web browser was used.

In the post message task, the new version of InkBlog demonstrated to have good performance in all devices. Fig. 4 shows the use of the Positivo Tablet to draw in the InkBlog using ten fingers at the same time (each line was done by one finger, draw here with different colors but the InkBlog just allow user to draw with one). The HP Tablet PC with Windows 8 recognized 4 fingers, instead of 5 fingers described in the operation system user manual. The Motorola Milestone and iPhone (Fig. 5) recognized 5 fingers.

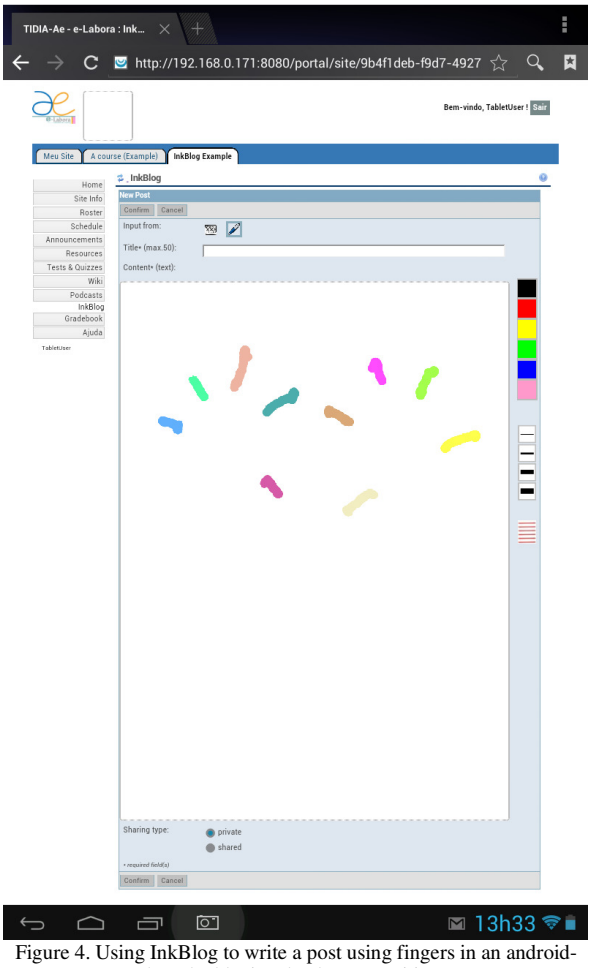

Figure 4. Using InkBlog to write a post using fingers in an android-based tablet in a landscape position.

All devices displayed the posts correctly (Fig. 6), but when the number of drawing posts increases, more time is necessary to render. The render process depends on the hardware, so different devices take different time to complete the task.

In all devices, smartphones or tablets, the touch input data was correctly identified by the web application. In Windows 8 using Google Chrome, the input data from the pen is recognized as mouse input.

To manipulate the iPhone and the Android-based smartphone we used fingers and a capacitive stylus. Since these devices cannot distinguish touches by fingers from touches by stylus, it is not possible to handling the input data considering the data origin. In this case, we prefer to allow users drawing on the surface instead of using the data to scroll the screen. We decided considering the user goal: to post a message.

Another handling is possible: to combine the power of input modalities, e.g., in Tablet PCs, devices that have capacity to distinguish the origin of the input data, it is possible to use the data from the pen to generate the electronic ink and the data from touch to scroll the screen or to trigger another gesture such as selection and zoom.

We did one study case based on user test (following Human-Computer Interaction methodology) planned to apply a profile questionnaire, the performance of four tasks and, in the end, apply a opinion questionnaire. In the opinion questionnaire we adopted the Likert scale for multiple choice

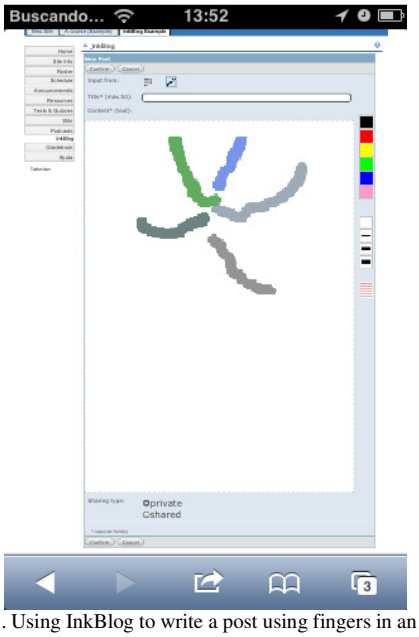

Figure 5. Using InkBlog to write a post using fingers in an iPhone smartphone in a landscape position.

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questions. We invited three volunteers: one woman and two men. One of them have post-graduation (33 years old) and the other two are undergraduate student in Computer Science (22 and 27 years old). All of volunteers consider themselves experts and use touchscreen devices every day for more than one year. None of the volunteers used pen-sensitive devices. All volunteers access Internet, one of them for more than ten hours per day and two of them uses between five to ten hours per day.

About e-learning environments, all volunteers have used: one of them does not know the name of the used environment and the other two had used TelEduc and Moodle. Two of them reported that they used for more than one year, and the another volunteer reported that she used between one to five months. Two users reported that they are experts about e-learning environment and another one reported have intermediate knowledge.

The volunteers were questioned about how to help a colleague that asked for help by e-mail to resolve an exercise that needs to apply the Bháskara formulae. One volunteer used special character to represent the power and the square in the formulae. Another one said that she probably sent a link with the formulae and some resolved exercises. The last volunteers answered that probably she will search on the Internet to remember the Bháskara formulae.

All volunteers performed four tasks: i) login (with a given username and password) in the Ae environment; ii) post a message in the InkBlog with the resolution of an exercise that need to find the roots of a quadratic equation; iii) aim a colleague to find errors in her resolution; iv) logout of the environment. The volunteers are asked to perform the four tasks in three devices: i) the Tablet PC using the pen; ii) the iPhone using fingers; and iii) the Positivo tablet using fingers.

By observation, it was possible to identify several problems. The volunteers had some difficult to do small traces (e.g., - and =); this traces are done quickly, and most of time, the interval between the start and the end is not long enough to generate the data; sometimes, the trace is recognized by the browser as gesture (e.g., back or forward). Dots are considered by all volunteers difficult to be done; since they are small, the user needs to press and move slowly the pen (or the finger) in circular move to do a dot. Maybe, these are the reason for the volunteers answered in the questionnaire, when questioned “It was easy write a message using a pen”, one user marked the option “strongly agree”, another one marked the option “agree”, and the last one marked “disagree”. One volunteer said that it was difficult to write as legibly as when she writes on the paper.

In the Tablet PC using the pen, the volunteers tried to scroll the page touching the pen in a white area (similar as they did when interact in smartphones). But, this feature is not implemented in the environment and the Chrome browser either. Maybe, this is the reason a volunteers mark “agree” when asked about if her had difficult to scroll the page. The volunteers reported that had some problems to use the virtual keyboard due the small keys.

About the interaction using the iPhone, the volunteers just used one finger to write in the InkEditor. The volunteers used two fingers only to do gesture for zooming. The

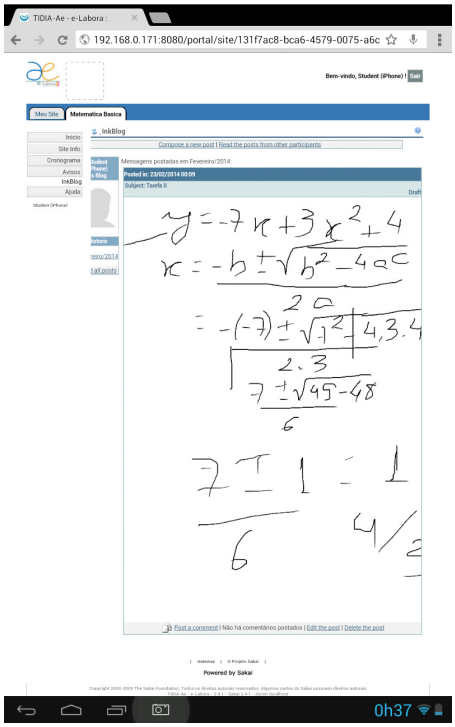

Figure 6. A resolution made by one volunteer with her finger about finding root for a quadratic equation rendered by Google Chrome browser in the Positivo tablet.

volunteers described some difficulty to read the screen, but they did not have difficult to trigger links and icons. One volunteer reported difficulty to scroll the page. About writing the resolution using the finger (question “it was easy write my message through the finger”), a volunteer marked “strongly agree”, another volunteer marked “agree” the last one marked “strongly disagree”. It is important to highlight that the exercise is easier to be done using a pen, due the pen characteristics. In the open question, one volunteer said “the iPhone screen is too small, and my fingers are large turn hard to do precise strokes and that fit in the available space” (Fig. 6). One volunteer reported the impossibility to do the gesture for zooming in the InkEditor component (InkEditor recognize as electronic ink).

About the interaction using the Positivo tablet, the volunteers reported that they did not have difficult to trigger links and icons, but one volunteer reported had some difficult to read the screen. No volunteer had difficulty to scroll the page (since a touch in anywhere in the screen can generate a scroll). About writing the message within a finger in the Positivo tablet (question “It was easy write my message using a finger”), one user reported “strongly agree”, another one reported “disagree”, and the last one “strongly disagree”. One volunteer reported (and it was observed too) that, after each trace done, the visual focus returned to the field text, and the browser scroll up the page, causing some risks in unwanted places in the InkEditor due the user started the next trace.

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V. FINAL CONSIDERATIONS AND FUTURE WORK

e-Learning environments are applications that use the Web infra-structure to support teaching and learning activities. To post text, there is a rich text editor to allow users writing formatted text without HTML (HyperText Markup Language) skills. This solution has good usability on desktop computers, but when the user interacts with a pen or touching, she needs to type each letter using a virtual keyboard, so the usability, most specifically, the efficiency, decreases and makes the writing task boring. Another problem is the difficulty to draw sketches using the mouse.

In our previous work we improved the Ae´s Weblog with components to generate and manipulate electronic ink, allowing users handwrite posts and draw sketches in pen-based devices, calling this new tool InkBlog (available to test at [17]). For the InkBlog development, we chose well-defined and promising technologies, such as W3C InkML and HTML5, allowing to codify a light electronic ink editor for Web pages, the InkEditor. Some modifications are done in the Weblog for distinguishing the correct editor to be displayed in the new post composite page and display handwriting posts and comments. However, InkBlog has some limitations: it is not possible, in touchscreen device, to use fingers to draw.

We believe that with InkBlog it is possible to have a better support to disciplines like Graph Theory and Computer Theory. Without the InkBlog, the user needs to use paper and pencil to resolve an exercise and use specific hardware, such a scanner, to digitalize the solution. Or the user needs to use a special application to draw a graph. In both solutions, the user posts the picture as an attached file in a weblog post. Using the InkBlog the user can sketch the graph directly on the weblog tool through direct manipulation.

In this work, we modified InkBlog to handling touch events, allowing users with multi-touchscreen devices post messages with draw done by fingers. The new version of InkBlog was tested in 4 devices (HP Tablet PC, Positivo tablet, Motorola Milestone smartphone and iPhone) and in 3 operation system (Windows Vista and 8, iOS and Android). Usability test was done with three volunteers. Some usability problems were found and they will be corrected in the next version. For future works, we will: 1) do a performance evaluation and evaluated in a class; 2) improve other tools by adding the developed components; 3) support gestures to trigger functionalities by the integration with the environment with a gesture recognizer, and study the gesture´s drawing for each function; 4) integrate with a handwriting recognizer to recognize the word and allow a better integration with another environment tools, such as search tools; 5) using a post or a document as background, allowing teachers or other student to do annotations about a post.

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Quixotic Potentialities of Information Communication Technology in the Running of Polytechnic Distance Education Programs in Nigeria

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***Abstract* - As Information Communication Technology (ICT) has become more and more popular in our life, researchers have begun to focus attention on its potentialities in the running of Polytechnic Distance Education Programs for the development of super-structures. In 1978, The Enugu State Broadcasting Service and Institute of Management and Technology collaboratively established the first Higher National Diploma Certificate Radio Program in Nigeria. This paper discusses the uses of Information Communication Technology in the running of Polytechnic Distance Education Program in the 21st Century. Also, its features, rationale, implementations, and challenges, as well as recommendations, are discussed. The impact of ICT is presented on what is learned, when, where and how, and how teaching and learning take place. This is to foster a generation of technological tools and technology-based information age. It has not been as extensive in distance education as it is in other fields in Nigeria, hence this study.**

Keywords-ICT; Distance Education; Technological tools; Information age.

I. INTRODUCTION

In 1978, the Enugu State Broadcasting Service and the Institute of Management and Technology agreed to run a Polytechnic Distance Education Program to carry out the social service functions of the Institute, apart from teaching and research functions. The program was introduced to respond to the growing needs of the society, which are not easily met by the traditional form of education in Nigeria [1]. The fundamental rationale for the program includes:

- To provide an opportunity for higher education for adults who, for different reasons, did not have the opportunity of early education.
- To complement the efforts of institutions of higher learning.
- To provide manpower needs for the nation
- To increase the number of well-educated citizens
- To provide general knowledge for the citizens

In Nigeria, according to official statistics, out of 43 million pupils who ought to be in primary schools, only 20 million are attending school. The implication is that over 50% of children of primary school age are out of schools. At secondary school level, 33.9 million students ought to be in school, but only 6.4 million are enrolled, translating to 27.9 million children out of secondary education. Even where access to education has improved, the school system is struggling to meet improved demands, but still the quality of education continues to suffer. In some states in Nigeria, hidden costs and lack of infrastructure still keep a large number of children out of school. There has also been a chronic under-investment in Early-Childhood Education and Adult Literacy programs. The outcome has been the prevalence of mediocrity and lawlessness in the society. These have led to more and more children joining the multitude of street urchins, suicide bombers, armed robbers, child laborers, Boko Haram and prostitutes, among others [2][3].

In today's competitive environment, productivity levels have a direct impact on the success of any nation. When a nation decides that improving productivity is its priority, there are three areas to focus on: technological productivity, worker productivity and managerial productivity. ICT is the power that propels this shared world. For any nation's economy to engage in profitable activity, experts agree that the workforce must be ICT compliant [4]. Today's world is driven by knowledge, which translated into efficiency and effectiveness in production. However, the case in Nigeria is different. This calls for a serious concern so as to save Nigeria's Polytechnic Distance Education Program from crisis.

ICT offers valuable opportunity for innovative delivery of effective learner-centered services with the advent of personal computer, CD, DVD, Internet, mobile phone, and other digital devices. ICT offers blended learning tools and instruments necessary to transform

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available technological and a variety of other forms of instruction at a distance, to deliver knowledge and skills to learners. Education is a socially legitimate knowledge that certainly helps individuals to obtain skills, better jobs, and higher salaries. The possibility of achieving success in this way in Nigeria is by making education and learning a need and a task for all. This requires bringing education and learning close to the people, developing and synchronizing local community's learning potentials and efforts within a comprehensive development strategy, with financial support [5].

The 21st Century is characterized by business development at Internet speed, short product cycle, short knowledge life span, changing literacy requirements, more career switching and continuous learning. In parallel to the flux of globalization, Nigeria has an urgent need for key strategies in re-building its competitive human capital to meet the new age challenges [6]. ESBS/IMT Polyair has taken some measures to improve practices online to ensure compliance and advancement in ICT development. Effective integration of ICT and pedagogical use of technology to bring Distance Learning transformation has been eagerly sought in the past four years. The strategic necessity of ICT in Distance Education Program (DEP) of ESBS/IMT Polyair has been inspired with a new face, the flexible Just-in-Time (JIT). "Distinct Blended Learning Approach (DBLA) for the 21st Century" can be taken at one's convenience, with a connected community. For example, e-tools, helpdesk by phone or e-mail and discussion forums are in place for learners. Learners are allowed to choose a mode of learning in Distance Learning (DL) courses. The ultimate aim of ICT in DL is to provide learners with the flexibility of study anytime, anyplace in a JIT mode. Study resources that help with Academic Advice, Technical Support and Peer Support are available via virtual learning environment at anytime and anyplace [7].

II. IMPLEMENTATION AND RATIONALE

Distance Education is not inherently learner-friendly. Adults choose to study part-time through this learning environment because it is the most convenient or the only educational option available. Adults choose Distance Learning because it offers a manageable way of combining study with family, work, friends and everything else they have to do. In all other respects, this is a demanding way to study, especially for a Polytechnic Higher National Diploma, which takes several years to complete [8]. Information Communication Technology has made Distance Education Programs attractive, cost-effective and easier by the use of blended learning implementations, such as Internet, intranet, CDROMS, Video and Audio cassettes, films, radio and television as well as telephone services. Tele-working, the internet and intranet CDROM, PC and electronic media are some distinguishing aspects of ICT. They are becoming increasingly used for DEP to respond to the growing educational needs which are not easily met by the traditional forms of education in Nigeria [9][10]. Some of the Distance Educational needs include:

i. To have courses for learners in scattered communities and caring for the socially and geographical isolated.
ii. Providing educational opportunities for adults who had no opportunity of early education.
iii. To bring into DE during Face-to-Face (FTF) expert knowledge, rare experiences and stimulating personalities
iv. To have cost effective program for a large number of learners.
v. To join hands with the Global Campaign on Education for ALL (EFA)
vi. To initiate National Campaigns which deal with health and political issues [11].

III. QUIXOTIC POTENTIALS OF ICT IN POLYTECHNIC DEP

Quixotic potentials of ICT in Polytechnic DEP include the following:

A. Learning Resources

The printed materials tend to set fixed boundaries to a course and can date quickly. ICT supports a model of resource-based learning and offering access to a vast store house of information, data and contact [12].

B. Greater Individualization

Distance Education has been likened to an "industrial" model of teaching, but from the learners perspective, the experience can feel like being an anonymous number in the system taking a standard course. ICT facilitates self-directed study and opportunities for individual research and projects. It also helps to break down the bureaucratic relationship between the individual and the institution.

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C. Greater Integration

ICT exposes the differences, but enforces a better integrated approach which enables the learner to move seamlessly from one area of activity to another [13].

D. Learning Community

ESBS/IMT Polyair learners welcome opportunities for contact and interactions with other learners and their facilitators and there is a program of FTF tutorial support. However, in a typical course, tutorials are neither frequent nor local. The use of e-mail and computer mediated conferencing has the potential to enable the learner to become an active member of a learning community with easy access to fellow students in their group, their tutor, students on the course nationally and the course team. The potentials of ICT in the new learning technologies will be to strengthen the sense of a learning community which is more accessible, personal, interactive and integrated, and, as a result, reducing the distance in distance learning.

E. ICT Potentials

ICT has the greatest potential for Distance Education which spawns human resources, social and economic development. It is said to be the single most pursued goal of nations. Information Communication Technology accelerates the development of students as learners through the provision of more materials for reading and more opportunities for simulation, problem-posing and solving [14].

It is envisaged that the introduction of ICT in ESBS/IMT Polyair program, software in learning and instruction will promote rapid dissemination of knowledge even to the excluded and also reduce the constraints associated with time and space. Moreover, the constraints have continued to swell the rank of illiterate Nigerians. The illiteracy rate in Nigeria is put at 57%. It means that, with an estimated population of 164,000,000, not less than 95 million Nigerians are illiterate [15].

IV. LECTURERS AND STUDENTS PERCEPTION OF ICT APPLICATION IN ESBS/IMT POLYTECHNIC DISTANCE EDUCATION IN NIGERIA

A total of one hundred and thirty lecturers teach in ESBS/IMT Polytechnic Distance Education Program. To find out the extent of application of information Communication Technology devices, seventeen questionnaire items were formulated. Statistically, Likert type 4 points scale was used to elicit responses from the lecturers, as shown in Table I:

- Very adequate (VA) = 4 points
- Adequate (A) = 3 points
- Inadequate (I) = 2 points
- Very inadequate (VI) = 1 point

TABLE I. RESPONSES OF THE 130 LECTURERS ON APPLICATION OF ICT DEVICES IN TEACHING AND LEARNING IN ESBS/IMT POLYTECHNIC DISTANCE EDUCATION PROGRAMMES

S/NO	APPLICATION OF ICT DEVICES	VA	A	I	VI	MEAN	RANK ORDER
1.	Mobile Phone Services	360	120	-	-	3.69	2nd
2.	Internet Facilities	-	150	20	70	1.85	9th
3.	Broadcast Radio Service	-	120	180	-	2.31	4th
4.	Broadcast Television Services	-	120	180	30	2.08	6th
5.	Computer Conferencing Service	-	-	20	120	1.08	12th
6.	Teleconferencing Services		-	20	125	1.12	11th
7.	Text Books	520	-	-	-	4.00	1st
8.	Video Conferencing	-	180	140	-	2.46	3rd
9.	Video Cassette Services	-	90	104	48	1.86	8th
10.	Slow-Scan Television Services	-	-	-	130	1.00	13th
11.	Laser Videotext Services	-	-	-	130	1.00	13th
12.	Telewriting Services	-	-	-	130	1.00	13th
13.	Satellite Conferencing Services	-	-	-	130	1.00	13th
14.	Fascimile Services	-	-	40	110	1.15	10th
15.	Video text Services	-	-	-	130	1.00	13th
16.	E-Library Services	-	90	120	40	1.95	7th
17.	Knowledge of Computer Usage	-	144	144	10	2.29	5th

Source: Survey, Report 2013

The data in Table I. above indicates that the mean score ranges from 1.00 to 4.00. Whereas item 7 has a mean score of 4.00, item 1 has a mean score of 3.69. All other items scored below the positive mean score of 2.5.

Table I shows that 2 out of 17 ICT devices ranked positive. This suggests that the application of information communication technology devices in the teaching and learning by lecturers is not yet satisfactory. Hence, the rationale for this study.

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TABLE II. RESPONSES OF 200 HND III STUDENTS ON THE USE OF ICT DEVICES IN TEACHING AND LEARNING IN ESBS/IMT POLYTECHNIC EDUCATION PROGRAMME

S/NO	APPLICATION OF ICT DEVICES	SA	A	D	SD	X	RO
1.	Text Books	800	-	-	-	4.00	1st
2.	E-Library Services	-	-	164	148	1.26	5th
3.	Broadcast Radio Service	-	600	-	-	3.00	2nd
4.	Broadcast Television Services	-	-	20	190	1.62	4th
5.	Internet Services	-	-	400	-	2.00	3rd
6.	Mobile Phone Services	-	-	400	-	2.00	3rd
7.	Knowledge of Computer Usage	-	-	-	200	-	6th
8.	Video Conferencing Services	-	-	-	200	-	6th
9.	Video Cassette Services	-	-	-	200	-	6th
10.	Teleconferencing Services	-	-	-	200	-	6th

Source: Survey, Report 2013

The data in Table II. indicates that the mean score ranges from 1.00 to 4.00. Whereas item 1 has a mean score of 4.00, item 4 has a mean score of 3.00. All other items scored below the positive mean score of 2.5.

Table II shows that 2 out of 10 ICT devices ranked positive. This suggests that the usage of information communication technology devices in the teaching and learning by student is not yet satisfactory. This calls for further studies.

V. CHALLENGES OF ICT IN POLYTECHNIC DISTANCE EDUCATION PROGRAMMES IN NIGERIA

Here are some of the challenges of ICT in Polytechnic Distance Education Programs in Nigeria:

A. Over-centralization of decision-making and lack of stakeholders' involvement in decision-making in Polytechnic Distance Education Programs. This encourages patronage of powerful special interests and high level of corruption therein.

B. Corruption diverts scarce funds from development projects and social safety nets into private pockets. In Nigeria, corruption related to weak governance and patronage-based politics has fuelled unproductive public investment. The opportunities for livelihood of Nigerians have been reduced, exacerbating poverty and conflict. With per capita income falling significantly to less than $300 between 1980 and 2011 (which is below the sub-Saharan average of $450), approximately 95 million of Nigeria's 164,000,000 people are living in absolute poverty and illiteracy.

C. Most of the lecturers in the Distance Education Program of ESBS/IMT, especially part-timers, can hardly be described as intellectually inclined either by training or in practice.

D. Misconception of what Polytechnic Distance Education Program is, has led to high cost of ICT, lack of professionals, lack of institutional readiness, dearth of logistics and poverty.

E. Economic constraints include: Limitation of capitalist system, corruption, inflation, inequality, insatiable appetite for the acquisition of material wealth (individualistic concern about cars, houses, clothes, and funds among other trappings of life).

F. Insecurity Problems
Job insecurity due to economic crises has led to mass unemployment. Also, this creates a feeling of helplessness among the nations.

G. Bad leadership
There is political instability, difficulties in communication and imperfections in organizational structure. Lack of serious political future for the participating stakeholders and their non-continued co-operation in the scheme are problems, too.

H. Lack of political will
Ignorance and misplacement of priorities are evident causes, too. Talents and experts are sacrificed for mediocrity. Worse still is the quota system of sharing political appointments in government programs.

I. Dearth of Experts
Dependency on Consultants outside Nigeria as a result of dearth of experts needed for the operation of ICT driven equipment for DE Programs.

J. Constraint of Power Failure
In Nigeria, power failure makes it difficult for learners to read after day-light and the high cost of purchasing mechanized and electronic devices is on the increase.

K. Worse still is the commercialization of the few available educational media in Nigeria. Also, non-maintenance of the collaborative agreement terms between the Enugu State Broadcasting Service and Institute of Management Technology

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on the effective running of Distance Education Program is a challenge.

L. Insufficient funds and lack of culture of preventive maintenance in ESBS/IMT Polytechnic Distance Education Program [15][16].

M. Lack of infrastructure
Most of the classrooms are dilapidated; lack seats, no light and above all, insufficient classrooms.

These challenges have posed terrible problems for ICT-driven Polytechnic Distance Education Programs, especially the ESBS/IMT Polytechnic Distance Education Program in Nigeria.

VI. RECOMMENDATIONS

For Information Communication Technology to thrive, no matter the potentialities in Polytechnic Distance Education Programs, there must be a realistic implementation strategy that has to work towards the factors below:

- Leadership by Example and Commitment
  Caring for peoples' needs, provision of suitable materials, provision of the right personnel and right environment and prudent management of available ICT.
- Practice of sharp-Networking: The relevance of networking includes that new ideas, vision and perspectives are elaborated and sharpened. Establishing a professional Association of Academic and non-Technical Distance Educators would enhance the most efficient and flexible mode of sharing information, experiences and ideas among likeminded persons, groups and organizations spread geographically and working on diverse issues.
- Readiness to rid the country of illiteracy: The political will should provide for promotion of research in motivation, evaluation and advocacy in ESBS/IMT Polyair Distance Education Program (DEP). The Management Committee requires some animators, conveners, or coordinators to act as models of energizing or sustaining information, ideas and resources among members and facilitators to ensure efficient ICT-driven DEP.
- There should be genuine incentives from the Management Board, School Board, Departmental Board and political leaders. This will help cure indifferences, apathy and ethnicism. It will discourage early withdrawals, and encourage visit to those who opt out and insist on proper record keeping. Inculcation of values of personal concern, personal-centered teaching, personal interest in each learner, tenderness, sympathy, etc., to strengthen social cohesion.
- Regular Publication of DE Journals and other Academic Periodicals. Exchange of ICT experts of member countries. Also, organizing regular conferences (nationally and internationally), seminars, workshops and short courses on ICT-driven DE helps in strengthening the openness and willingness to learn, as well as the responsibility of individuals.
- Research: For a program of ESBS/IMT Polyair to achieve the set goal in Education for all in Nigeria, the training must rest on sound foundation and to meet the needs of society and individual(s). It is essential that it should constantly benefit from the contributions of the ICT. This helps in strengthening the learners to choose, decide and behave rationally in the study.
- Management should build more classrooms for face to face contact. Also, ICT devices should be provided such as computers, CDs, DVDs, internet services, e-library among others. This is to encourage students to become ICT-compliant.
- To encourage lecturers to become ICT-compliant, laptops and constant training should be provided to them.

VII. CONCLUSION

In Nigeria, with regards to the Polytechnic Distance Education with particular reference to ESBS/IMT, it is clear that the use of ICT Devices in teaching and learning is still not encouraging. The management of the Polytechnic Distance Education program should provide ICT devices and training to both students and lecturers to improve the standard of learning and effective use of these devices. Also, classrooms should be built to enhance a conducive environment for learning. The fact remains that the learner must be assisted at every stage of his educational program progression by continually supplying the materials and the stimulus that the learners need.

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On Benefits of Interactive Online Learning in Higher Distance Education

Case Study in the Context of Programming Education

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***Abstract*—The advent of the world-wide web has challenged traditional distance teaching to supplement custom textbooks, video broadcasting and limited personal interaction with computer-based learning technologies, multimedia systems and compter-mediated interaction between geographically dispersed students and teachers. In this paper, we report on a project that aims to identify potential for improving learning outcomes of distance learners on the subject object-oriented (OO) programming through the use of new media and online learning technologies. We performed a quantitative and qualitative study based on a competence model for OO modeling and comprehension with two groups of distance students: a control group using classical textbooks and an examination group using a standard learning environment enhanced by digital interactive tools and re-purposed learning materials. In addition, we tracked the behavior of the online study group and analyzed the log data with the help of SAS Business Analytics to detect conspicuous learning behaviors.**

Keywords-distance learning; online learning; web log mining; learning analytics; competence analysis

I. INTRODUCTION

Traditionally, European distance teaching universities used prepackaged self-instructional correspondence courses that allowed their students to study at the time and location of their choice. Starting out in the early '90s, this teaching model was challenged by the advent of the worldwide web and, in succession, a rich world of digital learning and collaboration tools. This opened the opportunity to tailor course design to interactive online learning. As an intermediate step, we supplemented existing print courseware with interactive multimedia systems that allowed students to experiment with simulated or animated virtual worlds and get meaningful feedback on student-system interactions in real-time [1]. Asynchronous e-mail, chat tools, or text forums and synchronous webinars allowed us to narrow the distance between fellow students and teachers concerning social interaction possibilities.

Several studies have compared online and face-to-face learning, partly with contradicting result [2], [3], [4]. There is, however, a paucity of original research dedicated to understanding 1) whether information and communication technology (ICT) is perceived beneficial for distance education, 2) what the impacts of the use of digital interactive learning and communication tools on the outcomes of distance students in higher education, such as grades and test scores, is and 3) how learning designs should be tailored to meet the needs of these students.

A research project funded by the European Union [5] addressed the first question. It examined the impact of on learning in adult education, lifelong learning and, in particular, distance education. Research instrument was a series of randomized controlled trials using questionnaires and statistical analyses. The studies demonstrated conclusively that technology does, in fact, have a positive impact on learning. Major reasons include: technology facilitates easier access to material for those studying part-time; online communication facilitates the interaction with teachers, learning technology supports the development of higher level thinking skills, such as synthesis and problem solving, and digital learning materials including multimedia and interactive elements can enhance learning.

A first step towards answering the second and third question was recently undertaken in a joint project between FernUniversität and the University of Paderborn, Germany. The project set out to find answers to the following research questions:

1. To what extent can the learning objectives of a course be achieved with traditional custom textbooks and asynchronous tutoring activities using email, text forums, and phone?
2. Is there a significant difference in learning outcomes between students relying on traditional distance learning settings and online students?
3. Do students prefer online learning technologies to traditional correspondence courseware?

During summer semester 2012, we invited all 693 students enrolled in the distance learning course "Object-oriented Programming" for beginners to participate in a pre- and posttest evaluating the students' modeling and comprehension competencies in the topic area. Further, we asked for a smaller group of volunteers who agreed to study a new interactive version of a course module and allow us to

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log their online behavior. The competencies analysis used the Modellierungskompetenz-Modell (modelling competencies model, MoKoM) model that the researchers from Paderborn had developed in another research project that was financially supported by the German Science Foundation [6]. In a collaboration of computer scientists and psychologists, a theory based and empirically refined competency model for the domains of system application, system comprehension and system development was developed and tested by means of a competency test instrument [7].

In the following section, we present the project layout and sketch the research methods and tools used in the experiment and analysis of the data gathered by observation, competency testing, and surveys. Section III discusses the results of the competency, behavior, and the online learner satisfaction analysis. Section IV critically scrutinizes the validity of the results and outlines a modified design for a repetition of the experiment.

II. SETTING THE SCENE

Distance students own above average experience with self-directed learning. They are used to organize their learning freely but have limited time to participate in synchronous learning events, which requires the barriers for group learning actions to be kept low.

To challenge students in the online group to perform more demanding learning activities, we redesigned both the instructional design and the content of one module of the course substantially. The selected course unit dealt with exceptions, testing and program documentation. We developed a number of interactive learning objects in Adobe Flash that allowed the students to experiment with alternative solutions of program designs, explore, modify and explain the behavior of given program solutions rather than just sketching a single program on paper and submitting it as their solution to a homework assignment. To provoke teamwork, we designed learning tasks that involve 2-4 students playing different roles, such as a programmer or tester, and tasks whose solution was composed of several modules contributed by different students.

A. Competence model for informatics modelling and system comprehension

To define the important competencies for the considered domains, the MoKoM project derived a theoretically founded competency framework from relevant national and international curricula and syllabi. This framework was used as a basis to develop specific problem scenarios. They could be used to conduct qualitative interviews with experts in different fields of computer science education [8]. The analysis of the transcribed interviews led to an empirically refined competency model with six dimensions: K1 System Application, K2 System Comprehension, K3 System Development, K4 dealing with system complexity and K5 Non-Cognitive Skills.

For each competency described in these dimensions, a test item was developed for assessing it in large-scale competency tests. After some tests with smaller populations, the MoKoM project currently evaluates the results of an assessment of around 600 students. To deal with the large amount of tests, the instrument was split into 6 booklets with 30 to 40 items that could be completed in roughly 90 minutes each.

To use the instrument in the study at hand, we transformed the competency measurement instrument into an online version. Each item was adapted as close as possible into the online survey system LimeSurvey [9]. Due to the nature of the questions, some items could not be transformed properly (e.g., drawing a diagram). For each of these items, a decision had to be made, whether the associated competency was appropriate for the field of OOP and, if so, a new item had to be developed. As we wanted to exploit the breadth of the competency model and expected a high number of participants in the test, the partition into six booklets was kept for the online survey.

To allow for an anonymous survey, an additional item was added to ask for a unique code. This code was generated individually for each student based on personal information.. This allowed for the association of pre- and post-test without revealing the students' identity.

B. Study Groups

In a first step before the course started, we invited all 693 students enrolled in the course to evaluate the online test. To raise the students' interest in the study, we announced to give away three books in a raffle based on voluntarily provided email addresses. The 146 students who followed this request and worked on the test with different degrees of completion formed the study group for the competency test.

Then we invited students who agreed to study the online course module and allowed us to track their behavior. 12 volunteers formed the online student group whose behavior we analyzed and whose satisfaction with the e-learning version of the course we studied.

At the end of the course, we asked the whole student population again to evaluate the post-test marking it with the same code they had used in the pretest.

Finally, we aimed to differentiate between online and textbook students among those who participated in the obligatory written exam, which is held at the end of the course, in order to find possible differences in the learning outcomes of both groups. 199 students took the exam including 6 of the 12 online students. Both groups were truly comparable because they are all distance students enrolled in the same study program. In addition, the online students also have experience with textbook study materials from other course units of the test course and other distance courses in the curriculum.

C. Digital Learning Environment and Learner Satisfaction Analysis

The online course unit addressed exactly the same course topics as the textbook version but included more experimental learning components and a few cooperative

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tasks. Figure 1 depicts an interactive learning object, which is called crash lab. It allows students to explore the behavior of programming exceptions by pulling selected program statements from a pile underneath a program window into a code-frame provided in that window, compile the resulting code and run it if the compiler succeeds. Students are supposed to predict whether the different programs they build this way will fail or terminate successfully. The results of the test runs are collected in the two boxes labeled "aborted" and "regularly completed" at the bottom right.

An example of a team problem is a simple game with a treasure being hidden in an area of 24 cells in which a player to find the treasure by moving in this area strategically. One student has to develop the program component controlling the game; the partner has to implement the behavior of the player. Some constraints are imposed on the behavior of both components, which may lead to program exceptions. Raising and handling exceptions properly are key learning objectives of this course unit.

The online course was delivered through the learning management system Moodle and was supervised by the same faculty who also taught the textbook version. The installation of Moodle we used in the study was seamlessly connected to the learning object repository edu-sharing [10], [11]. This repository enabled the online students to share and collaboratively work on their contributions. The repository functionality allowed them to control which access rights to their personal workspace they wanted to grant selected peers.

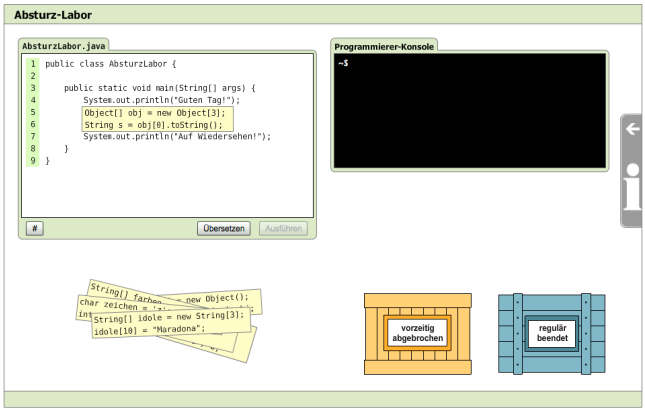

Figure 1: Crash lab supporting explorative programming experiences

Besides the students' online behavior, we also wanted to understand their satisfaction with the online course material and with the learning environment we provided. For this purpose, we designed an online questionnaire with 28 questions addressing the following issues: preferred computer equipment, experiences with e-learning, usability of the online course and tool environment, subjective judgement of the discipline knowledge, communication and cooperation competencies gained in the online course, and a comparison of the effectiveness of the study process with traditional textbooks and the online study material.

III. Analysis of Results

A. Competence Analysis

To assess the competency gain of the students, they were asked to complete the online survey created from the MoKoM measurement instrument twice: Once at the start of the term and once at the end. The students were randomly partitioned into six groups, each having access to one of the six test booklets provided in a LimeSurvey installation at FernUniversität in Hagen,

Unfortunately, the participation in the survey was not very good. Of the 693 students registered for the course, only 57 started their pretest booklet and just 19 students in total finished more than 75% of all items. This number got even worse for the post-test with 30 started booklets and only 5 finished surveys. At both tests intervals around 150 users visited the survey page but only one third and one fifth, respectively, started the first item at all. Since the participants who finished their booklet were spread across the six variants, the useable data for each test item is too low to get any meaningful results regarding the competencies of the students. Only one student completed both tests, what makes propositions about the competency gain through the course impossible. Even tendencies supporting or falsifying any of the hypotheses we started from are hard to state.
To at least get a notion what to change for subsequent tests, the answering habits of the participants were examined. By counting the number of students who tried to solve an item over all 87 datasets it is easy to see that the completion rate drops to 60% after only four items (see Figure 2). The eighth item was completed by only 50%.

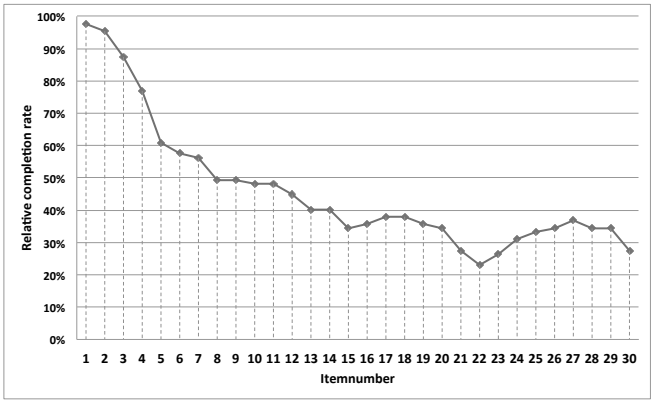

Figure 2: Relative completion rate of survey items

A reason for these results might have been the length of the competency test. Tailored to be conducted in a German classroom setting, where two successive lessons equals 90 minutes, it seems the time a student is willing to spend on his own in answering the survey is considerably shorter. Examination of the response rates for online surveys even showed that the ideal length for an online survey is thirteen minutes or less [12]. This ideal timeframe is too short for a competency test, but without the constraints of a school environment, 90 minutes seem much too long.

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B. Behavior Analysis of Online Students

It is obvious that the small number of cases (12) cannot provide statistically valid results. Even so, some insights gained are worth mentioning.

The database for the behavior analysis of the online students was compiled from the log data provided by Moodle and edu-sharing and the log data captured by the Flash-based interactive learning objects. The latter allowed us to a) relate student results to assignments, b) see errors he or she trapped into, and c) find repetitions performed in the attempt to solve an assignment. As user identities for the login to Moodle and edu-sharing (single-sign-on), we used the personal code the students had defined for the pre-test. All log data were time-stamped. These time-stamps helped use to integrate the data coming from different sources. The raw data were cleaned and integrated to a single database that was then analyzed with the help of the business analytics software SAS. SAS was particularly used for structure and usage mining. Structure mining relies on the links between information pages and links from within course pages to self-test examples, homework assignments, forum entries, and objects maintained in the repository and workspaces.

The objective of structure mining is to identify recurring patterns of behavior, e.g., in the form of paths through the learning materials or repeated experiments with exercises and programming problems. These paths form a network that visualizes how students navigate through the course material and the learning environment. The open source software Gephi Data Laboratory [13] was used for network analysis and result plotting. Particular indexes of the network analysis are the weighted in- and out-degrees of course elements, which indicate the frequencies of visits. The master solutions to self-tests in the sections about exceptions and program testing and a quiz about program comments had the highest values: 35, 34 and 30, respectively, while the average was 9.9. Another index is the connection intensity between elements. It records navigation steps leading from one to another element in the graph. A high index value between an information page and a self-test indicates multiple trials of this test and suggests a higher degree of difficulty of the problem exposed. This index may help the course author to vary the degree of difficulty of self-tests in a distance-learning course as it is perceived by the students. The index "page rank" also identifies the master solutions for self-tests on program testing and exceptions as top candidates. A path analysis shows that students work through the first part of the online course mostly following the structure provided by the course author. In later parts, however, their behavior is more flexible.

Usage mining provides useful descriptive statistics. This includes:

- information about the number of page visits,
- time spent on a page, exercise, or problem, usage depth or
- typical entry and exit pages.

The usage depth in this experiment tells us that, in the average, 35 course elements were touched in a single visit.

The quantitative analysis described above was complemented by a qualitative analysis based on the log data captured from the interaction with Flash objects. For instance, five students worked on the explorative problem depicted in Figure 1 and all five predicted the behavior of the 8 different program snippets correctly. This result suggests that the difficulty of the problem was too low. A test of the students' ability to understand the semantics of exceptions, which was composed of 4 sub-tests, shows that the success rates diminish with each sub-test. This observation confirms the author's intention to increase the difficulty of the sub-tests step by step. An investigation of problems in which students had to write code reveals that one student performed significantly worse than his or her peers. His behavior seems to exhibit a trial-and-error strategy as opposed to the structure procedures the other students applied.

C. Test Scores

Originally, we wanted to relate the test scores of the exam to the competences test to investigate whether the self-evaluation of the students correlated with the examination scores and whether we can find significant differences between textbook and online students. We also hoped to see whether an initial difference in competences in the topic area has a significant impact on the exam result. In addition, we were curious whether the course can even out such competency differences in the student group. Further we were looking for differences in test scores between textbook and online students.

Figure 3 shows a plot of the frequencies of scores for the 199 students who took the exam. The best score (1.0) was achieved by 8 students, 57 students failed with a score higher than 4.0. The lower curve shows the frequencies for the six online students, which roughly follows the shape of the other curve with 4 students scoring between 1.3 and 3.0 and two students having failed.

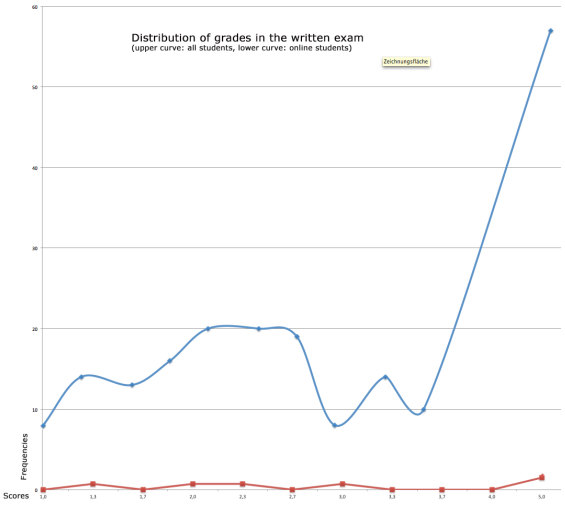

Figure 3: Scores of 199 students in the final exam

Knowing that this interpretation is, indeed, daring, we hope to perform better in an ongoing second experiment with about 100 online students.

 ISBN: 978-1-61208-328-5

D. Learner Satisfaction

In order to analyse the online-students' needs and their satisfaction with the online version of the course, we developed a web-based questionnaire that was also accessible via LimeSurvey. We adopted and enhanced the Technology Acceptance Model (TAM) [14], and the System Usability Scale (SUS) [15]. Both were already successfully applied to analyse e-learning environments [16], [17]. The questionnaire provides 28 Likert-scaled statements and covers 9 analytical dimensions. They are:

- use of the learning environment's technical functionality,
- potential to convey expert knowledge,
- potential to convey methodological skills,
- usability of the learning environment,
- patterns of usage,
- types of exercised co-operative learning,
- use of platform's communication tools,
- students' motivation, and
- students' technical affinity.

The questionnaire was delivered at the end of the term to those students, who attended the online-course and also agreed to participate in the behaviour-analysis study based on their log-files. Unfortunately, only six students responded. Thus, it does not make sense to deploy statistical methods of quantitative data analysis on this sample. Nevertheless, the students uttered some interesting statements, which might contribute to the comprehension of existing problems. The addressed categories were: importance of a good mentoring service, necessity to be aware of the system's functionality, students' personal situations and missing pressure to succeed lead online-learners to drag behind the schedule of the course, this additionally creates barriers for co-operation and communication with fellow students.

IV. Conclusion and Future Work

The underwhelming results of the first survey led us to conduct a second iteration with a slightly different concept during the winter term of 2013. To get more students to finish the test, it had to be possible to complete it within 60 minutes. For this reason, instead of testing the complete range of competencies of the MoKoM model, a collection of items especially tailored to the requirements of the course at hand was selected. To choose the appropriate test items, the desired learning outcomes for the programming course were matched to the competency descriptions of the MoKoM model. This way, a selection of relevant test items could be accumulated and combined into one competency test. This also eliminated the need for several test booklets and will allow for a bigger set of data for each test item.

Since the complexity of the item did not allow for a test with the suggested optimal length of thirteen minutes, an additional incentive had to be made to complete both tests. For this reason, we decided to offer bonus points up to 10% of the total number of credit points that can be achieved in the exam. Up to half of admissible bonus points will be given for participating in both pre- and posttest, the amount depending on the degree of completion of each test. The other half will be granted for participating in the online study group, depending on the degree of activity and collaboration. Those students who want to compensate their bonus points with the exam result have to give up anonymity against the examiner, but their personal data will not be accessible in the competency analysis. The bonus points can only be used in the exam offered immediately after the end of the course. This constraint renders us quite optimistic that the students who volunteered for the competency test and online behavior analysis will take the exam and thus give us the chance to compare the learning outcomes of a reliable sample.

So far, the measures seem to be successful, since the pre-test performed late September 2013 showed a tremendous increase in the number of participants, with around 180 complete or nearly complete datasets.

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Mitigating the STEM Crisis through Enhanced Online Learning

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Abstract – **According to the U.S. Department of Commerce, Economics, and Statistics Administration, in 2010 7.5 million people were employed in science, technology, engineering, and mathematics (STEM) jobs and accounted for 5.5 percent of the workforce. The report also stated that these occupations are projected to grow at a rate of 17.0 percent outpacing non-STEM jobs which are projected to grow only 9.8 percent. However in 2012, despite there being nearly 14 million unemployed people in the U.S., American companies could still not find workers skilled enough in math and technology to fill an estimated 3 million permanent job openings. The lack of trained skilled STEM workers has often been called the STEM Crisis. There are many researched reasons some argue that if there really is a STEM Crisis, why it exists. However, much of the traditional reasons, while still very valid have given way to reports that academic unpreparedness and lack of STEM literacy may be in part the cause for the shortage of STEM workers who possess a broad range of competencies and experiences. The response to this challenge has become the focus of many states, encouraging partnerships and collaborations between colleges/universities, K-12 schools, and public and private sectors. The aim of this paper is to present an effort to abate the STEM crisis through restructuring content delivery in an introductory computer science course taught a two-year institution. The paper presents the context in which the work is framed, the course design and delivery of the enhanced online learning experience, results from the study, limitations and future work.**

Keywords – Complete College America; enhanced online learning experience; learning content management system; STEM; undergraduate computer science education

I. INTRODUCTION

According to the U.S. Department of Commerce, Economics, and Statistics Administration, in 2010 7.5 million people were employed in science, technology, engineering, and mathematics (STEM) jobs and accounted for 5.5 percent of the workforce [1]. The report also stated that these occupations are projected to grow at a rate of 17.0 percent outpacing non-STEM jobs which are projected to grow only 9.8 percent [1]. The report further stated some of the characteristics of the STEM workforce which include that they earn on average 26 percent more than their non-STEM counterparts; more than two-thirds have at least a college degree; and, that they are less likely to experience joblessness when compared to their non-STEM counterparts [1]. Moreover, for women entering into STEM careers, they are likely to earn 33 percent more than women in other occupations [1]. Consequently, these statistics paint an advantageous portrait of why more students should choose STEM disciplines in college and why so much emphasis has been placed on STEM education. However, a common theme at the *U.S. News & World Report* STEM Solutions 2012 Leadership Summit in Dallas, Texas, was that despite there being nearly 14 million unemployed people in the United States, American companies could not find workers skilled enough in math and technology to fill an estimated 3 million permanent job openings [2]. The lack of trained skilled STEM workers has often been termed as the STEM Crisis.

The STEM crisis can be likened to the software crisis of the late 1960s and 1970s, in which software had to "catch up" to its more complex and powerful machines, thereby making informal software development no longer feasible. As a result, software engineering brought formal processes, methodologies and accountable to improve the quality of software being developed. Similarly, in the case of the STEM Crisis, formal processes are being developed and implemented to improve the quality of students/workers being trained for and entering into STEM-related careers. However, just as the answers to solving the software crisis was complex, understanding why the STEM Crisis exists and how to mitigate it is as well.

There are numerous researched reasons as to why some argue that there are not enough skilled STEM workers. For example, according to The New York Times' Christopher Drew, studies note that approximately 40 percent of students who choose to pursue a STEM area either switch their major in college or do not graduate at all [3]. This statistic, as stated by Drew, is twice the combined attrition rate of all other majors [3]. While others suggest that societal stereotypes, environmental and cultural factors, a lack of visible role models, different interests and experiences, are some of the reasons that students do not choose STEM [4]-[7].

Yet, according to the National Math and Science Initiative, a public-private partnership led by private donors and U.S. corporations, it is the declining number of students who are prepared to take rigorous college courses in science and math and who are trained for careers in those fields that has fueled the STEM Crisis [8]. ACT, Inc. reported that in 2011, 45 percent of U.S. high school graduates were ready for college-level math while only 30 percent were ready for

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college-level science [9]. Consequently, for the U.S. to regain its competitive edge states are developing and implementing strategies to improve college-readiness especially in areas that depend on science and mathematics skill sets. Moreover, states are also investigating ways in which to improve access and student success once students enter the halls of academia. This paper focuses on one strategy to improve student success by restructuring content delivery through and enhanced online learning experience introduced in a traditionally taught introductory computer science course taught at a two-year institution.

The paper is organized into the following sections. Section II introduces the Complete College plan, an initiative undertaken by states to increase the number of students completing and earning college degrees or certificates and in specific areas that will help strengthen the U.S. economic prowess. Sections III and IV introduce the environment in which the study was conducted and present the enhanced online learning experience. Sections V and VI present the results and discussion from the study. While Section VII presents limitations, challenges, future work and concluding thoughts.

II. THE COMPLETE COLLEGE PLAN

A. Complete College America

In response to the concern that the U.S. is lagging behind other countries in its production of college-degree holders, Complete College America emerged in 2009 as a national non-profit organization whose mission is to work with states to increase the number of Americans with career certificates or college degrees [10]. Since its inception, 34 states, including the District of Columbia have become Alliance members and are now participating in working to significantly increase the number of students who are successfully completing college.

To become a member of the Alliance, the state's governor in partnership with its colleges and universities pledge and work together to meet the Mission of Complete College America [10]. More specifically, when a state becomes an Alliance member it makes college completion a top priority and commits to do the following [10]:

- Set completion goals
- Collect and report common measures of progress
- Develop action plans and move key policy levers

B. Complete College Georgia

The state of Georgia is an Alliance member and has adopted the Mission of Complete College America, which includes that by the year 2020, 61 percent of young adults will hold a college certificate or degree. Georgia also notes that in order to improve the state's economy that another 27% of Georgians must join the already 34% of the states' population who currently hold an associate's degree or higher [11]. To meet this goal, not only must the colleges and universities in Georgia enroll more students, but they must retain the ones currently enrolled and remove barriers that impact student success.

In Georgia there are two public systems, the University System of Georgia (USG) and the Technical College System of Georgia (TSG). In 2011, leadership from the two systems met along with state leadership and representatives from the business community to receive a charge from the Governor on ways to change the higher education funding formulas to incentivize degree completion [12]. The result was an Articulation Agreement between the USG and the TSG. The Articulation Agreement proposed to:

- Create new forms of collaboration and accountability among organizations responsible for or reliant on higher education
- Continue to work with the Georgia Department of Education to increase the number of college-ready students graduating from high school
- Reevaluate and envision anew the performance of completion-related aspects of higher education

More specifically, approaches to improve low completion rates included [11]:

- Building and sustaining effective teaching
- Exploring and expanding the use of effective models
- Distance education
- Adult and military outreach
- Implementation of STEM initiatives

C. Georgia Perimeter College

Georgia Perimeter College (GPC) is a two-year institution located in the Atlanta-metro area, part of the 35-member schools of the USG. GPC offers Associate degrees in Arts, Sciences and Applied Sciences [13].

GPC typically hosts the largest freshman and sophomore enrollments in Georgia, making it the top producer of transfer students to 4-year institutions within the state of Georgia. It has five campus locations and services approximately 23,000 students. The number of students choosing one of the STEM disciplines is roughly 10 percent [14]. The average age of the student population is approximately 26 years old and 59 percent of the students are enrolled as part-time students, meaning that they take less than 12 credit hours during the semester [15]. Further, roughly 10 percent of the students take all their classes online [15].

In response to Complete College Georgia, GPC created the Office of STEM Initiatives. The mission of the Georgia Perimeter College Office of STEM Initiatives is to promote student access and to improve student success in the STEM disciplines. The goals of the office are to:

- Increase the success rate of students in STEM "gatekeeping" courses
- Provide educational opportunities and support for students choosing STEM disciplines as a major

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- Deepen student and faculty engagement in college-wide STEM activities
- Support, connect and strengthen collaborations to advance STEM preparation for P-20 students and faculty
- Develop and support exemplary practices and policies in STEM education at the 2-year college level

To encourage faculty members to engage in activities that improve student success in STEM-related areas, the Office of STEM Initiatives developed the STEM Faculty Mini-Grant Program. The goal of the GPC STEM Faculty Mini-Grant Program is to support faculty who engage in innovative research-based projects that:

- Restructure current instruction delivery models
- Develop new models for building and sustaining effective teaching
- Impact student learning and performance through enhanced learning experiences

The next section describes the author's activities developed to meet the goal of increasing the success rate of students in STEM "gatekeeping" courses with a specific emphasis on CSCI 1300 – *Introduction to Computer Science*. CSCI 1300 is the first course for students interested in pursuing a computer science career and normally has a high attrition rate.

III. INTRODUCTION TO COMPUTER SCIENCE

A. Course Description

CSCI 1300 – Introduction to Computer Science is designed to provide students with an overview of selected major areas of current computing technology, organization and use. Prerequisites are exit or exemption from all Learning Support, English as a Second Language (ESL) requirement and successful completion of College Algebra [16]. For computer science majors, the course is a prerequisite for successive courses within the program of study. For other majors, the course meets the requirements of the common core in the area of science, mathematics and technology from which students must choose.

B. Topics Covered

Since the course is a commonly taught course, all students are presented with the following topics [16]:

- The history and vocabulary of computers
- Problem-solving, algorithms and algorithm efficiency
- Data representation and storage
- Computer hardware and software concepts
- Computer networks and information security
- Programming concepts and problem-solving
- Application software and Databases
- Social and ethical issues

C. Learning Outcomes

The learning outcomes are designed by the course curriculum committee. It was decided that by the end of the course, a student should be able to [16]:

- Discuss the history of computing.
- State the methods by which data is represented and stored in a computer's memory.
- Recognize and understand the fundamental hardware components of a computer system.
- Recognize and understand the fundamental software components.
- Understand the concepts of current communication technologies.
- Understand basic networking and information security.
- Recognize and understand social and ethical issues involved in computer use.
- Analyze a basic real world problem and solve it with a computer program.
- Understand and write algorithms using fundamental computing concepts.

IV. ENHANCED ONLINE LEARNING EXPERIENCE

A. Participants

As previously stated the course is designed for and utilized by students who have chosen one of the STEM disciplines as a major. At GPC, the STEM majors are Biology, Chemistry, Computer Science, Engineering, Geology, Mathematics and Physics. During the fall 2013 semester, 28 students enrolled in the course; however, seven of the students withdrew prior to the midpoint of the semester and therefore the number of participants in the study is 21. Of the 21 students, the majority was computer science majors, 53 percent, followed by 33 percent engineering majors, 5 percent physics majors and an additional 10 percent had not declared a major in one of the STEM areas. Moreover, the class consisted mostly of sophomore students, 62 percent. The average age of the students was 25 and the class was comprised of 90 percent male and 10 percent female. All students were associated with a "home" campus, meaning that none were identified as online students.

B. Procedure

Researchers note that there has been a dramatic shift in the way in which students learn [17]. Technology supported learning provides students with an opportunity to view online situations and examples that help to aid the learning process. Additionally, technology supported learning has been shown to be beneficial to students who are visual learners rather than auditory learning [18]. It has been noted that students process visual information 600,000 times faster than text, and visual aids can improve learning by 400% [19]. However from a delivery perspective, technology

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supported learning provides a semi-permanent resource which allows students to re-visit the clips, thereby increasing the potential to develop greater understanding of the material.

Consequently, it was decided that the PowerPoint slides that the author typically used in class, would be modified to include an enhanced online learning experience. The slides were revised to include voice narration on the lecture topic, narrated problems usually solved in class and educational videos. Students were encouraged to view the lectures prior to coming to class. Unlike the traditionally taught modules where the lecture slides were covered in class as part of the class period, the material developed for the enhanced online learning experience was to be viewed out of class so that the class period could be utilized for answering questions and working practice problems.

Both the traditionally created lecture slides and the enhanced online lecture material were posted in the Colleges' Learning Management System, Desire2Learn (called iCollege by GPC). The author chose to post the material in iCollege because all enrolled students have access to it and it has features that allowed the instructor to gather statistics on who viewed the slides and for how long.

It was decided that the programming concepts and problem-solving module would be best suited for the enhanced online learning experience. The author chose this module because it was the implementation of the theoretical concepts learned earlier in the sixteen week semester. Moreover, the author thought that the students would benefit more from the hands-on experience and practical application associated with the module as compared to previous topics. Table 1 presents the order in which the modules were presented and the associated assessment.

TABLE 1. CONTENT DELIVERY

Week	Module Topic and Number	Assignment Number
1	1- Introduction to Course and History of Computing	1
2	2 - Representing Algorithms	2
3	3- Attributes of Algorithms	3
4	***In Class Exam #1***	
5	4 - Binary Numbering System	4
6	Boolean logic and gates	
7	5 - Components of a computer system	5
8	6 - Basic networking	6
9	***In Class Exam #2***	
10	7- Programming Concepts	7
11	Programming Concepts	
12	Programming Concepts	
13	***In Class Exam #3***	
14	Application Software	
15	Ethical Issues	
16	***Final Exam***	

V. RESULTS

To determine the effectiveness of the enhanced online learning experience, the following data were collected:

- Average viewing time spent on all lectures
- Number of viewers per module
- Student performance on assignments
- Student performance on exams
- Results from a student survey

A. *iCollege Results*

The results revealed that on average, students spent approximately 24 minutes and 54 seconds reviewing the lectures posted in iCollege. There were between two and six lectures created per module. This number varied depending on the complexity of the topic. Figure 1 presents an overview of the viewing time spent per module.

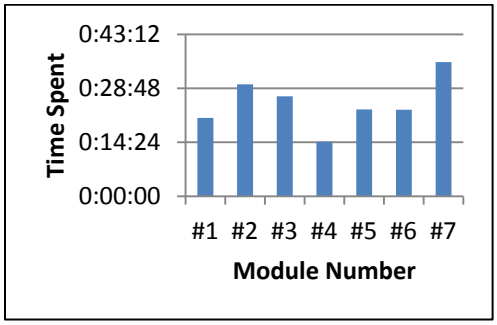

Figure 1. Average time spent per module

The results also revealed that of the 21 students who completed the course, the number of viewers per module was roughly 18. Figure 2 shows the average number of viewers per module.

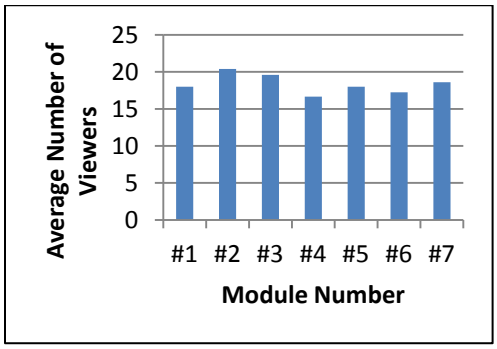

Figure 2. Average number of viewers per module

B. *Student Assessments*

The author also wanted to assess the impact of the enhanced online learning module on student performance. After the completion of a module, an assignment was given. Figure 3 shows the results of student performance according

to the module. Module #7 is the enhanced online learning experience.

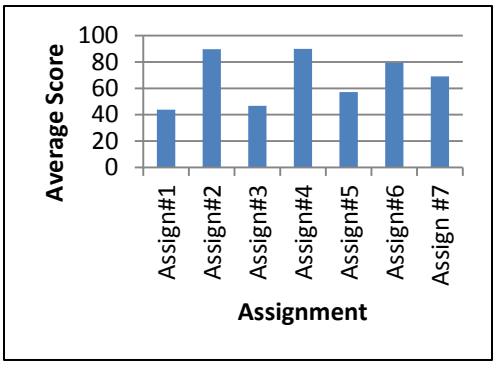

Figure 3. Average Score per Assignment

Figure 4 shows the results of student performance on the three exams administered, with the only content for exam #3 being that taken from the enhanced online learning module.

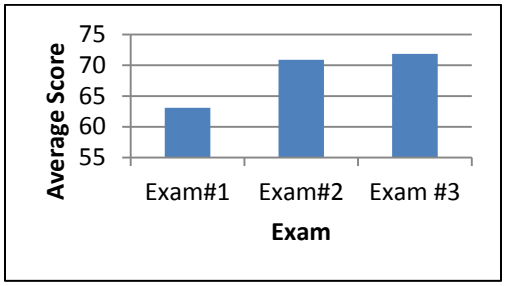

Figure 4. Average Score per Exam

C. Student Survey

Lastly, a brief survey was distributed to the students after the completion of the enhanced online learning module. The purpose of the survey was to get a better understanding of students' perception on the inclusion of future enhanced learning modules in the course. Figure 5 presents the results.

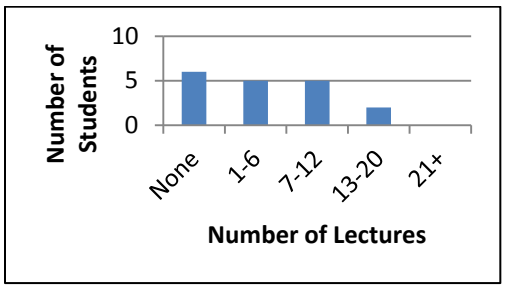

Figure 5. Desired Number of Enhanced Online Lectures

Additionally, the author had previously proposed a hybrid course based on the flipped classroom model. As part of the survey, the author also asked if students would consider enrolling in a hybrid course for CSCI 1300. Figure 6 presents the results.

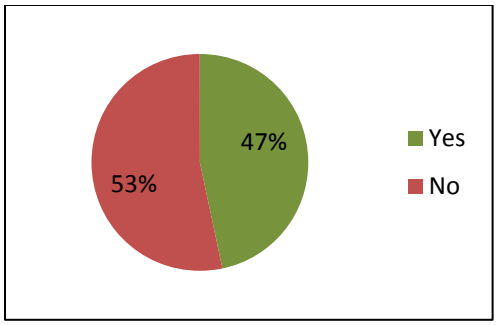

Figure 6. Hybrid Course Results

VI. DISCUSSION

The results revealed that students spent on average 35 minutes and 50 seconds on the enhanced online learning module which is roughly 12 minutes and 47 seconds more than the average time spent of 23 minutes and 3 seconds, viewing the traditionally created lectures posted in iCollege. While this is not a substantial difference, it is consistent with what the author anticipated, which was that students would spend more time viewing the enhanced online learning module because the material covered would not be face-to-face as with the other modules. Furthermore, this result shows that although it has been reported that on average students' attention span is around 8 to 10 minutes long during a traditional long [20] , students will engage in enhanced online lectures for a longer period of time. However, it was surprising to the author that the average time spent viewing the enhanced online learning module was not higher. But because this module was the implementation of module #2, algorithmic development, which had the second highest recorded viewing time, the author believes that the students felt more comfortable with learning the syntax of C++ because many of theoretical concepts had been previously covered (i.e., selection statements, looping, and evaluation of expressions).

The student performance data on the assignments also showed no substantial difference between the face-to-face modules taught and the enhanced online learning module. However, the exams scores show a remarkable difference and indicate an increase of knowledge from exam #1 to exam #3. When asked, students indicated that they felt more comfortable and better prepared to take exam #3 as compared to exams #1 and #2. However, the author considers the result from this data inconclusive, because there are many variables that may have impacted student performance which include, the technology supported learning of the enhanced online modules as well as students' self-efficacy.

Lastly, the student survey revealed that while some students wanted to include enhanced online lectures as part of their learning experience, others did not. This result can also be seen in the response to the question on whether students would want to take CSCI 1300 as a hybrid course. Fifty-three percent of the students stated that they would not

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take the course as a hybrid offering, while forty-seven percent stated that they would. The author finds this result to be one for future investigation as hybrid courses offer both the face-to-face component blended with the flexibility of online learning. Moreover, because 59 percent of GPC students are enrolled part-time and roughly 10 percent of the student population takes all their classes online, the author anticipated that an overwhelming number of students would enroll in a hybrid computer science course. Yet when asked, students expressed concern of "having to learn this difficult material on their own" and they also wanted a traditional environment because "this is my major and I want to be prepared."

VII. CONCLUSION

The aim of this paper was to present the results from a study that investigated the restructuring of content delivery in an introductory computer science course to include an enhanced online learning experience. The results revealed there was no significant difference in viewing preference or student performance, which leads the author to question the impact and effectiveness of the enhanced online learning module. The study further revealed that when students were asked if additional enhanced online learning modules should be included as a part of the course, the responses were mixed. Students' concerns of "learning difficult material on their own" and not "feeling prepared" are validated in studies like those conducted by the Community College Research Center at Teachers College, Columbia University, of students enrolled in Washington State Community and Technical Colleges. The study found that the students enrolled in online classes were more likely to perform poorly and also less likely to complete their degrees and/or transfer to a 4-year institution [21].

However, there are some limitations to the study which impact the author's findings. The author notes that the use of PowerPoint, even with the enhancements made may have reduced the effectiveness of content delivery. Another limitation of the study is the point of introduction of the enhanced online learning module into the course. The restructured content delivery experience was introduced after the midpoint of the semester which may have influenced students' performance. For future work the author proposes to mix the delivery of content among modules, instead of between modules. Lastly, for future work, the author intends to introduce as a compliment to the learning experience, student-developed enhanced online lectures to investigate their impact on lecture viewing and performance.

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Faculty Perceptions of "The Project": An Advanced Faculty Professional Development for Online Course Building

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Abstract—**This article reports on a research study that focused on faculty perceptions of an advanced professional development workshop (called "The Project") in relation to designing and teaching online courses at the university level. The findings of the study, gleaned from an end-of-course survey, revealed that the faculty members perceived a focus on advanced technology users favorably and deemed it would contribute to developing future online courses.**

Keywords-e-learning; faculty perceptions; online course building; online learning; professional development

I. INTRODUCTION

Online education has grown considerably in the past 10 years as demonstrated by the fact that the proportion of students taking at least one online course has increased from fewer than one in ten in 2002 to almost one third in 2010 [1], [2]. Along with this growth in demand for online courses has come increasing pressure from administration in institutions of higher education for faculty to provide more and more online course offerings [3]. These factors have also generated a demand for more faculty training related to building and teaching online courses [4], [5], which is the focus of the study presented here. The distinguishing factor of this study is that it evaluates the implementation of an advanced faculty professional development program for online course building. Furthermore, *advanced* is used to refer to the faculty members who have been trained in online course development and teaching, are experienced online course builders, and who have taught online courses previously.

This paper documents the effectiveness of the program based on the perceptions of the faculty participants as determined by their responses to an end-of-program survey. The paper begins with a review of the literature associated with advanced professional development for online course building and its role in developing online courses and programs. Then, the design of the advanced faculty professional development program for online course building is detailed, along with the research method that was used for this study. Next, the results of the program evaluation and a discussion of the faculty perceptions are provided. Finally, the article concludes with broader implications of this research through a discussion of how the results from the program evaluation will enable course instructors to optimize instructional design to improve the professional development program in future iterations of "The Project."

II. LITERATURE REVIEW

Studies confirm a substantial increase in the availability of online courses and programs in recent years [1], [2] and research related to online course development continues to be consistent with the creation, implementation, and facilitation of training for faculty new to online teaching. The motivation behind this line of research is the increasing requests for online course offerings and programs from students and therefore the increasing pressure for institutions to provide more online course offerings. Consequently, research about the effectiveness of online training models is also more in line with the needs of students [1], [6], [7] and the concerns of faculty new to online teaching with little or no mention of advanced faculty who develop online courses [8], [9], [10], [11].

Furthermore, there is a considerable amount of research that examines the effectiveness of the transfer of learning (TAM) models and the ease of use among faculty when training for online teaching [9], [12]. For example, Agarwal and Prasad [12] describe how training affects the participants' perceptions of usefulness for the technology, and that people more highly educated or trained with the use of technology are more likely to adopt technology for teaching. More directly related to this study, Gegenfurtner, Veermans, Festner, and Gruber [13] found that the way the person perceives training may impact the decision to apply knowledge gained from the training. In an analysis of current and effective training strategies for preparing faculty to teach online Lackey concluded that online "preparation strategies should include both technical and pedagogical training" [14].

Professional development for online instructors, in both online and face-to-face formats, can create effective informal learning whereby participants in the training collaborate, share, discuss and reflect on different technologies, pedagogies and practices [15]. In this way, participants construct knowledge and transfer learning with each other. It is anticipated that this experience would be heightened and even more beneficial in an advanced faculty online professional development program where the participants already have online training and online teaching experience. However, researchers have not yet investigated such perceptions of implementing an advanced faculty professional development program, as addressed by this study. The specific research questions addressed in this article are the following:

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1. How do faculty perceive the effectiveness of an advanced professional development workshop designed for online course building?
2. What changes do faculty recommend making to the advanced professional development workshop designed for online course building?

III. METHODS

This inquiry-based research focused directly on faculty perceptions of advanced online teacher training. To answer the research questions a 15-item questionnaire (see Appendix A) was administered electronically to the 10 faculty participants. The questionnaire was designed to determine whether the participants deemed the faculty development as valuable. Furthermore, the survey was designed with the Technology Acceptance Model in mind to ascertain whether the participants planned to use information and tools presented in the project. It was created and delivered via SurveyMonkey, a cloud-based application for surveys, which made the questionnaire more accessible. Subsequently, all participants completed the questionnaire, which was designed primarily to gauge the participants' perceptions of having participated in and completing the professional development course. The analysis of the survey responses targeted the participants' satisfaction or dissatisfaction with the course and its specific components. This focus was adopted to gather information in an effort to answer the research questions and to refine the course for future use.

It should be noted that the relatively small sample size of this research (N=10) limits the generalizability of the findings. Therefore, the presentation of faculty perceptions regarding the advanced faculty workshop for online course building should be considered in context and only applied to other contexts of comparable nature. To bolster the generalizability of these findings, larger samples should be studied over longer periods of time**.** Self-reported data, like that gathered in this research, comes with a bias of judging your own work. "The Project"

To address the increasing demand for online and hybrid courses at the university under investigation and the need to provide faculty with the skills and incentive to develop these online and hybrid courses, the advanced professional development workshop, known as "The Project," was created to provide faculty within the college who are already teaching online with advanced tools and pedagogy to develop future online courses. For the first iteration of "The Project" online modules were created and run by online coordinators, designated faculty within each academic department in the college who act as a liaison between department faculty and the Office of Distance Education (ODE) in the college. The online coordinators also served as the first participants for the project. The group consists of five females and five males; one full professor, four associate professors, three assistant professors, and two lecturers. Collectively, the group had an average of 6.3 years of online teaching experience and 10 years of technology-enhanced teaching experience. Additionally, all members had at least one year as an online coordinator.

Online coordinators are given a small stipend for taking on the responsibility of supporting distance education in online, hybrid, and traditional classroom settings within their department. This support can include department level training for instructional technology and one-on-one sessions to brainstorm and trouble shoot distance learning issues with full-time and part-time faculty. With the guidelines that it should pertain to best practices and sharing knowledge and expertise relating to online learning, and that it should contain 30 minutes to one hour worth of content on their topic along with an interactive activity, the online coordinators were given freedom to select their own module topics. Additionally, each module designer was expected to monitor his or her own module during the week that it was active and to provide feedback to participants. The eleven modules created and presented are depicted in Table I.

TABLE I. OVERVIEW OF LEARNING MODULES INCLUDED IN "THE PROJECT"

Learning Modules
Module 1: Latest Research Into Successful Online Learning
Module 2: Best Practices in Mobile Learning
Module 3: Faculty Presence in Online Courses
Module 4: Get Your Students' Heads INTO the Clouds: Cloud Computing
Module 5: Strong and Effective Types of Feedback
Module 6: Taking the Long View: How Online Learning Has Changed at the University
Module 7: Lessons Learned: Five Tips I Would Share with New Online Coordinators
Module 8: Creative Assignments in the Online Classroom: The Virtual Classroom
Module 9: Learner-Content Interaction in Online Courses
Module 10: Real Online Programs at the University
Module 11: Social Media in Online Teaching

"The Project", being a completely online professional development workshop, was hosted on the learning management system Desire2Learn. Each participant was expected to log in each week to access the module contents and participate in the activities, completing the module in one week. There were no incentives for the online coordinators to participate in "The Project" other than it was expected as a part of their position. Most modules contained voiceover PowerPoint presentations for content delivery, although two modules used a PowerPoint presentation with more detailed notes. Modules dealt with contemporary pedagogy and technology related to online teaching, including cloud computing, the use of social media, the edupunk movement, teaching on mobile devices, and showing user-content interaction with simulations using ArcGIS. Every module started with module objectives and some modules had supplemental or required readings. All modules had a discussion board where participants were asked to reflect and interact through answering one or two directed questions relating to the material covered. Frequently, participants were asked to relate their own

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experiences and methods of achieving a particular goal, such as establishing instructor presence in an online course. This participation sometimes involved asking participants to share samples from their own courses. Some modules used drag and drop exercises and self-assessment quizzes to verify content comprehension and retention.

IV. RESULTS

The following sections delineate the results from this study as they relate to the research questions. More specifically, the results are presented in order of the survey items. With regard to question one, a small majority (60%) of the participants who completed the questionnaire (N=10) expressed some apprehension about the purpose of and time commitment associated with "The Project" at the outset, and none expressed "excitement" about their participation .

Despite this initial trepidation, the participants reported a noticeable increase in enthusiasm for the training after completing the project. Only 50% responded that they were either "enthusiastic" or "somewhat enthusiastic" before training and 90% responded similarly after completion. The increase in interest was further reinforced by qualitative responses like, "Once I started seeing the very interesting contributions, I thought it was brilliant," "I think there are some potential benefits of completing this course," and "I see potential for this, but it needs refinement."

Although all of the participants (100%) reported being satisfied with the online delivery of the training, consistent themes in the qualitative feedback provided across questions focused on the potential benefits of this training and the need for content revision. Most of the participants reported that this training with modifications would effectively serve our experienced faculty who desired additional professional development. Several participants commented on a need for additional technology modules. Another concern focused on the overall lack of consistency across the modules, which was likely a product of having individuals develop content without restrictive guidelines about what they should include prior to initial launch.

Recognizing, perhaps, that "The Project" is being developed for delivery to experienced faculty who have previously developed and delivered online and/or hybrid courses, participants identified the "Pedagogy/Online Teaching" modules as most helpful. Several also responded either quantitatively or qualitatively that the modules specific to the university and the role of online coordinators were the least helpful of those offered.

Across several open-ended questions, #5 and #8-12, additional feedback was collected about revising the existing modules to improving content in "The Project." Qualitative comments centered on the duration of the training, a need for more consistency in both content and facilitation across modules, and the addition of more content focused on technology. Notably, a majority of participants reported a willingness to offer more than just constructive feedback about their experience; 80% of the respondent indicated that, if asked, they would create another module for the "The Project".

V. DISCUSSION

Based on faculty responses to a 15-item questionnaire, three findings emerged from the study's results. These findings include the following key points: First, participants generally reported enthusiasm concerning their professional development experience in "The Project." Second, most participants identified pedagogy as the more important topic covered in "The Project." And third, "The Project" functioned as a knowledge and skill benchmark for its participants. A more detailed explanation of each finding follows.

A. Enthusiasm for Professional Development

Whereas more than half of "The Project" participants did not understand the program's purpose up front or feel they had time for it, most participants reported enthusiasm or some enthusiasm for "The Project" at its completion. Several of the open-ended responses, many of which are summarized previously, substantiate this conclusion. This observation fits with the findings of Baldwin and Magjuka [16] in that it confirms the importance of thoroughly explaining a training program to faculty members well before training commences. In short, participants are routinely more willing to participate in any type of training program if a program's initiator has taken steps to clarify the purpose of the training. We attribute some of the enthusiasm for "The Project" upon its completion to the presence of what Bolt [15] refers to as "informal learning" which occurred when participants shared their preexisting knowledge and online teaching experiences with each other. By sharing their "very interesting contributions" (per a comment on the survey) relating to online teaching, participants created an online community of learning and practice. In effect, with this advanced professional development course the transfer of knowledge from participant to participant became equally, or even more, important than the transfer of knowledge from course facilitator to participants. In line with previous research [17], [18], [19], this finding demonstrates that structured learning programs – whether facilitated by a designated professional trainer or co-facilitated by participating trainees – are a constructive means to influence the development of one's advanced online instructor abilities.

B. Pedagogy and Professional Development

A second finding of this research is that the participants of "The Project" distinguished pedagogy as the most important topic in the program for furthering one's online teaching abilities. Indeed, 60% of participants noted that of the 11 modules in the program, covering four online education topic areas (i.e., Online Coordinator duties, technology today, trends in online education, and pedagogy for online teaching), the topic deemed most valuable to the program was pedagogy for online teaching. Ninety percent of participants believed they were improved online teachers based on their "The Project" experience, especially due to content that emphasized pedagogy. These comments substantiated this finding: (I liked) "hearing about pedagogy and theory related to teaching online!" and (I liked) "lots of details about online pedagogy." This second finding fits with

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Stephenson's [20] perennial work on online education that emphasizes the importance of pedagogy to online instruction. This finding also supports the significance of the growing body of pedagogical theories being taught in training programs for online instruction and being referenced and tested in social scientific research (e.g., Technology Acceptance Model [12] and Theory of Action [17]). Specifically, the Technology Acceptance Model suggests that the perceived usefulness and ease of use of the technology will increase the users' acceptance of the tool.

As a cautionary note concerning this finding, it is not clear whether participants distinguished pedagogy as most important in "The Project" because the topic is associated with a broader call for increased emphasis on pedagogy at the university-level or because the increased time demands for teaching online (e.g., mastering new and evolving technologies) takes away from time that might otherwise be spent incorporating pedagogical principles in teaching; either way, "The Project" results establish that instructors who already teach online recognize the need for pedagogy as they continue to develop as online instructors. These results lead us to concur with Lackey's [14] previously stated view about the importance of including both techniques and pedagogy in online training strategies.

C. *Self-Assessment and Professional Development*

In addition to the first two findings, results of this research produced an unanticipated third finding. "The Project" functioned as an online teaching knowledge and skills benchmark for its participants. In terms of background, participants qualified for "The Project" because they already had experience teaching online and serving as online coordinators for their departments. In particular, the mean amount of online teaching experience for the online coordinators was six years. As inconsequential as this amount of experience may seem, knowledge of online teaching appeared to function as a mitigating factor influencing participants as they processed content during the program and evaluated content at its end (e.g., actively comparing and contrasting modules). Their feedback was evident in the program's evaluation at its conclusion. As one participant noted, "(I) absolutely (find this information valuable), if the content is improved." While another participant offered, "I thought some of the modules were good, while others were not especially applicable. There is definite need for improvement." In brief, "The Project" seemed to tap into a collective knowledge of online learning that helped differentiate high-developmental modules from low-developmental ones. This emphasis on cognition is significant in that it acts as a predicator of learning transfer [9].

By the same token, participants also acknowledged the importance of continued skill development as part of their experience in "The Project." As Burke and Hutchins [9] as well as Gegaenfurtner, Veermans, Festner, and Gruber [13] note, emphasis on skill development is an important component of any effective instructor development program, especially for one focused on online teaching. Several responses support attention to online skills training: (a) "There needs to be more consistency in the quality of modules." (b) (In the future) "build into this project various course assignments that relate to the required deliverable" (e.g., a new course)…(that) require(s) faculty to critique and provide feedback on the posts or work of their colleagues." (c) "Facilitator(s) must model what we should be doing in the classes." In sum, "The Project" served as a meaningful knowledge and skills assessment for its participants as they worked to enhance their online teaching abilities.

VI. CONCLUSION AND FUTURE WORK

The favorable results demonstrate that "The Project" yielded a basic structure from which an advanced faculty development program could be built. There are tangible benefits to be derived from the informal learning that comes with an advanced and experienced online faculty community of learning and practice. There are also several practical implications to consider. First, through participant feedback, the ODE learned that participants believed the pedagogical components of "The Project" to be the most valuable. Second, participants desired more technological teaching tools in the training, and third, participants believed that the online coordinator-specific modules were the least valuable.

TABLE II. OVERVIEW OF LEARNING MODULES INCLUDING PLANNED MODIFICATIONS FOR "THE PROJECT"

Category of Module	Name of module
Pedagogy/ Online Teaching	Latest Research Into Successful Online Learning; "Faculty Presence" in Online Courses; Strong and Effective Types of Feedback; Learner – Content Interaction in Online Courses; Work Smarter, Not Harder*; Improving Retention in Online Courses*
Trends	Best Practices in Mobile Learning; Get Your Students' Heads INTO the Clouds: Cloud Computing; Creative Assignments in the Online Classroom: The Virtual Museum; The Use of Social Media in Online Teaching
Technology	Panopto*; SoftChalk*; VoiceThread*; Tiki Toki*; Doceri*

*Content was added for a future iteration of "The Project"

As can be seen in Table II, coordinator-specific modules were removed for the advanced training version of "The Project", and five additional modules were added for specific technologies. In addition, two modules on pedagogy were added: "Work Smarter, Not Harder" with timesaving tips for online teachers and "Improving Retention in Online, Hybrid, and F2F Courses" with research-based strategies and templates for improving course retention. Future iterations of "The Project" will be offered as a skills update workshop in which the participants choose and complete 9 of 12 available modules.

As noted in the introduction, this study provided a unique opportunity to examine faculty participants' perceptions of an advanced faculty development for online course building.

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Although the findings of this research yield positive results, several areas merit future research. First, similar research should include the perspectives of non-researcher participants and draw from a larger sample size. Second, researchers should evaluate the transference of technology skills as a result of completing the workshop. Last, future research should examine the impact such workshops may have on student learning. Such future research will provide a fuller picture of how the advanced faculty development workshops impacts faculty teaching and students' learning.

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APPENDIX A: SURVEY ITEMS

Question 1: What were your thoughts when you were first introduced to the idea of "The Project"?

- I didn't really understand it
- I felt like I didn't have time for it
- I thought it was interesting
- I was excited

Question 2: Before "The Project" began, please rate your enthusiasm for it.

- Not enthusiastic
- Somewhat enthusiastic
- Neutral
- Enthusiastic
- Very enthusiastic

Question 3: After completing "The Project," how enthusiastic are you about the experience?

- Not enthusiastic
- Somewhat enthusiastic
- Neutral
- Enthusiastic
- Very enthusiastic

Question 4: Do you believe that this workshop, with a few modifications to make content more specific to online faculty, will effectively serve faculty who have completed the "Build a Web Course" Workshop and desire more professional development?

- No
- Somewhat
- Can't say/don't know
- Yes

Question 5: Do you like the fact that it was all online?

- Yes
- No
- Don't know
- Other

Question 6: What category of modules was most helpful to you?

- None
- Pedagogy/Online Teaching
- Trends
- Technology
- KSU/Online Coordinator Specific
- Other

Question 7: What category of modules was least helpful to you?

- None
- Pedagogy/Online Teaching
- Trends
- Technology
- KSU/Online Coordinator Specific
- Other

Question 8: After completing "The Project," do you believe that you are a better online teacher?

- Yes
- No

Question 9: After completing "The Project," do you feel that you are a better online coordinator?

- Yes
- No

Question 10: What did you like least about "The Project"?

Question 11: What did you like most about "The Project"?

Question 12: What changes would you make to better serve your faculty who enroll in "The Project" pilot in fall?

Question 13: If asked, would you participate in creating another module for a similar endeavor such as "The Project"?

- Yes
- No

Question 14: How much should faculty be paid to complete "The Project" in a semester (not creating modules, just attending/participating)?

Question 15: What else would you like to share?

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Training Oriented Mobile Device to Learn Software Architecture

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***Abstract*—Teaching new technologies has two facets. A first facet is the pleasure to discover new concepts with beginners. The second facet is the difficulty to create the right training for students who will apply this knowledge through an internship by the end of the training. Since January 2013, our challenge has been to prepare a new training about nomadic device and Android programming. Our training is structured as a master's degree in our UPEC University (Paris). This document presents both aspects of this master degree: the construction of the training and the perception of teaching activities by the students. We observe that the use of a tablet or a smart phone during the lessons is not enough. Pragmatic approach is limited even if it is a help for the participation of students, and a motivation for teachers and students in a computer science context where it is crucial to explore new domains. Learning with device provides a more practical teaching. But its use has to be completed by knowledge validation with it. Because devices take place into teaching approach, the whole process of teaching has to evolve into a more interactive exchange between teachers and students.**

Keywords-mobile device; distributed system; software architecture; teaching mobility.

I. INTRODUCTION

Software systems become more and more complex and now new devices have to be taken into account. Smart phones and tablets bring a new software facet: the mobility. A more accurate word would be nomadism [1], because, it allows users to exploit software applications during a movement between two locations. Mobile devices [2] can further be defined as having the ability to receive and/or transmit voice, text, data, messages and/or Internet usage without a cable connection. Also new application domains can be sketched. For instance, the use of mobile devices allows photograph and record public information and transfer data easily with a timestamp.

These new features involve new difficulties, and the need of training appears more and more essential. Previous example introduces the need to store data locally to a device, they need to exchange data over the network. Also, it appears today that a tablet or a smart phone does not support the same kind of software [3][4]. A database server cannot be installed on such device, neither a mail server. Also, applications on mobile devices are often client application of remote services which are implemented on more traditional servers. The important concept is the available binding for the exchange.

This highlights that mobile devices provide a plethora of possibilities for sensitive information to be accidentally leaked into the public. It includes local data, pictures, text messages, phone numbers, permissions, and more. Again, the need of security management seems to be crucial.

Mobile technology is now being used in classrooms. Also, it seems natural to offer basic to advanced instructional mobile technology training for students. It appears clearly that mobile technology encourages creativity and hands-on learning with features not found in any other educational tool, on a device that students really want to use. From this, we have created a series of lessons around mobile technologies. The first year allows us to have the first results presented in this document.

We present our work as follows. A first section is about the training creation process and how we have built a training oriented device (TOD). The next section is on the role of the mobile device during the courses: its impact on the teaching and also on the work of the students. Next, we detail our results during the academic year and the process of internship selection. Finally, we propose a new objective for the next academic year and the consequence on our teaching approach.

II. TRAINING CREATION PROCESS

Mobile devices are becoming increasingly valuable within the computer science teacher community for both training and concrete applications [5]. So, our teaching team was ready to use tablets for presentation. Each teacher had bought his own portable tool and appreciated his own choice because of its instant feedback, its large selection of applications or the wire free teaching. Our approach to creating computer training required to choose a material to support all the teachings. Next, we present our criteria and how they were validated.

A. Material selection

Creating training with mobile device does not always mean eLearning. In our context, this creation for display on mobile devices involves handling different mobile platforms, designing appropriate content and adapting existing content for different classes of devices. Also, a kind of tablet should be selected before the start of the academic year (September in France). A family of criteria was enumerated by the teachers. There was reliability, an enjoyable interface, the energy efficiency, a camera, remote monitoring, and so on.

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We classified these criteria into three classes: the criteria required by the teachings, the criteria required for students, the criteria required by the Institute [6].

1) The criteria required by the teachings: tablets are highly portable, touch screen, Internet enabled, handheld computers. These basic features are common to a set of material, but additional features are required for our teachings. First, the wireless network course requires that the equipment has the capacity for Bluetooth, WIFI, but also connections between other USB type (version 2). Next, Android programming course requires to install a version greater than 4.2 because the graphical user interface toolkit is richer and bugs were fixed. In particular, drawing is optimized for layers, clipping and certain shapes. Next, the system course presents the management of sensor, camera and Near Field Communication (NFC) hardware interface.

2) Tablets vary in the way they organize the screen layout. The 4:3 aspects are more suited to being used in portrait mode and this is why the home buttons are positioned for that orientation of use. The 10' category is a good size device. Teachers should also consider using larger devices where possible, especially if they are using classroom management software and have a lot of information on their screens at any one time.

3) The criteria required for students: during the academic year, the students have to prepare presentations where the mobile device is important. To make it easy to show content on an external display, the device has to provide a special ability to render the content of a screen according to the characteristics of the targeted display. Moreover, the students need to exchange data between tablets or between a tablet and other Bluetooth devices. Also, the Bluetooth stack implementation version is as important as the Java Application Programming Interface (API). Each student has to develop Java applications and it could be suitable to have a rapid access to all need sensors through a Java API.

4) The criteria required by the Institute: The management of devices is not trivial in an academic institute. Especially, when problems occur, such as a breakdown, a process of repairing has to be subscribed before. Also, it is interesting to have only one kind of tablet for all the students of the master degree. Moreover, the tablet was given to a student for the duration of the school year and students are asked to pledge in writing. So, everyone should be responsible for his actions. The budget was also one of our primary concerns and the Android option was preferred because the prices are also affordable, even if the number of tablets was more than twenty. Google education packages are another feature which supports the choice of such kind of tablet where teaching applications are available.

B. Training plan construction

At the beginning, our training goal was to provide training to master students on the mobile device. The trainees will learn skills on the programming and management aspects of mobile devices and how to set and run the applications.

1) The objectives of the training: we wanted to train our students on a new skill (mobile programming) and to refresh them on things which they already knew such as distributed architecture. After the master degree, our students will have to easily find mobile application development jobs Jobs for mobile application developers are at an all-time high and continue to show no sign of slowing down. This means that we defined courses adapted to the market. We will be going to assess if the training has met its objectives, whether the internships are success and students have future first jobs.

2) People who are going to train: The trainees are new students, which means they will be learning a whole new skill set. They come from other universities and some of them come from other countries where training organization respects other rules. Because students have to work together, they also have to learn how to work in project mode. This means developing responsible and autonomous learners. The teachers are frustrated by their unmotivated students. But what they may not know is how important the connection is between student motivation and self-determination. Mobile programming is considered in a positive manner by new students. Their mobile smart phone or tablet is the mirror of what they are. Also, they consider as an identification, the knowledge of the mobile device. This is their connection point of social networks, also the motivation is deep.

*3) Material suitable for the trainings:*the iteration of our criteria helps us to select Android devices from several constructors. We did three kinds of tests:

a) Robustness: this is the degree to which a device operates correctly in the presence of exceptional inputs or stressful environmental conditions [7]. We have run a set of applications which need to use the WIFI connection or Bluetooth protocols. We have used external device: *Secure Digital* (SD) Card and USB connections, the impact of multi connections on the efficiency. Finally, we have validated the multi touch screen and its behavior depending on the size, the precision [8].

b) Technical capacity : Benchmarking applications are useful for measuring the performance of mobile devices and comparing the scores with similar devices. We have defined three benchmarking applications for Android devices that we used to see how the device measures up [9][10]. They test the performance of processors, graphics systems, Web browsing, and more.

- Quadrant Standard Edition (QSE) tests CPU, I/O, and 3D graphics. After running through the tests, we have been required to submit the score to the

 ISBN: 978-1-61208-328-5

company's servers in order to see the results. The bar chart shows our overall score and compares it with other devices.

- Linpack is a benchmark that's been used to measure the CPU performance of some of the world's fastest computers. We have used the same benchmark to test all Android tablets. The final score is given in Million Floating Point Operations Per Second (MFLOPS) and is a quick and simple test of the device's performance.
- Vellamo measures the Web browsing performance of Android devices in 4 categories--rendering, javascript, user experience, and networking. It also checks the ability to request and to respond to servers.

All the applications mentioned above are free from the Android Market.

c) Simplicity: Tablets now provide continuing advances in our search for simplicity of use. They have to allow developers to create simple ways to do things. We have checked the automatic plug and play through USB connection. But the control is also on the recognition into applications. For instance, developers use Eclipse *integrated development environment* (IDE) for programming and debugging. For tablets it is necessary to restart the platform server, for others it was automatic.

4) The kind of training: There are many factors when choosing a course of study or training. We have the traditional training style where the focus is on the teacher and the training session is very much content-driven. In this style, we say that the learning depends on a teacher. The use of mobile device involves the introduction a new facilitator style of learning that is focused on the learner. This style is process-driven and the learning takes place independently, without the teacher. A key to motivating students is helping them to see that, indeed they can take responsibility for their own learning. So, a part of each lesson is letting students work together with other students to meet learning goals. Also, we have defined three learning mode:

- Traditional learning mode: this corresponds to the first part of each lesson.
- Facilitative learning mode: the second part of the lesson where students have a responsibility to apply what they have previously learned. This mode also applies during project option where students work in group.
- Programmatic learning mode: the last part of the academic year is a six month internship. The students are in a more concrete context where their skill can be validated by results.

5) The schedule over the year: The academic year is divided in half. The first half has mainly courses and the start of the project option. The second half contains an important place in the project option and ends with the internship. We have scheduled the first part of the year as follows:

- Project management course
- Methodology and functional specifications writing
- Architecture and drafting of technical specifications.
- Web architecture for nomadism,
- Performance evaluation,
- Change management,
- Computer science law,
- Databases for mobile device,
- System and network programming for mobile,
- Programming for mobile phone and tablet,
- Mobile networks and wireless networks,
- First part of project option,

The second part of the academic year is divided as follows:

- Software engineering,
- Business simulation,
- Design patterns for web applications,
- Mobile architecture for cloud,
- Security policy,
- Performance and quality of service,
- Last part of project option
- Internship thesis,

The scheduling of the course is to adapt best to the project option. Traditional teachings stop in April. Then, the internship begins; in parallel, the project option continues. At the end of June, students have to validate their project option. The defense of internship leads to a probation report and an oral presentation in early September.

6) Transforming the plan into actions:

When the training plan was built, the next actions were the construction of the list of concerns per lesson. This is done by the person responsible for training. The aim is to validate that:

- There is no overlap between training.
- The number of lessons is enough for the list of concerns.

The next actions were the construction of the activities per lesson. Because concern is presented to the student during the first part of the lesson, then they have to practice. So, pragmatic activity has to be prepared with the material (mobile device). This allows the teacher to measure useful time to realize this activity and the material constraints which are required.

C. Validation plan

In the evaluation phase, we will determine if the students obtained the knowledge, skills, or attitudes we identified as the goal during the analysis phase. Using the information we will obtain during the evaluation phase, we will make additional changes to the design, development, and delivery of the training program the next academic year we offer it to students. The assessment validation provides assessors with an opportunity to:

- Evaluate the technical quality of the training and assessment tools being used,

 ISBN: 978-1-61208-328-5

- Develop some benchmark performances,
- Discuss issues of concern about the training delivery and assessment process,
- Suggest improvements for training delivery processes and assessment tool design.

The validation plan is the process of determining that our requirements are the correct requirements and that they form a complete set of initial requirements. This will have consequences on the next student selection.

III. DEVICE IMPACT INTO TRAININGS

The technology constantly changes; if we incorporate technology in our master degree, it is imperative for us and our students to be current.

A. Tablet role into lesson

A student is unlikely to master new technology on his own accord. For this reason, we have incorporated mobile technology training in the classroom. Also, we have included mobile software applications to help facilitate or organize the work's tasks. First, tablet is the support for the course called "Programming for mobile phone and tablet". This means that developments are realized on the laptop and experimentation is done on the tablets. This course provides an overview of the most common programming environments for mobile phones and students learn how to program on mobile devices. The teacher can validate that experimentations are really done. By small examples and hand-on sessions, students are able to create their own applications. Besides the general overview, focus is on networking issues with mobile devices. Besides simple client/server examples, also peer to peer networks are discussed by the teacher.

The course called "Web architecture for nomadism" is built to explain how mobile devices running Android can be incorporated in Web architectures. The web is evolving very fast to provide the same functionality to web-apps that standard desktop applications have. Students have to develop Web activities using standard web technologies as much as possible on their own mobile device. For example, a case of study is to take a picture from the device camera, and that is possible with web standards. Then, the mobile application uploads the image onto a web server by the use of Representational State Transfer (REST) service.

Other experimentations are done in the course called "Databases for mobile device". Mobile databases, like sqlite are popular because mobile devices have become need based and common. One key aspect of these database systems is their ability to deal with disconnection. We experiment Extensible Markup Language (XML) graph database on the tablet. Through a lesson, the teacher explains when the device is not protected properly all the data stored in the device are exposed to outsiders. So, security for the database that resides on the mobile device is crucial for organizations. Also security concerns are introduced by the end of the course.

During the course entitled "Mobile networks and wireless networks", protocol exchanges are studied. Also, students have to understand how a mobile device communicates with other devices even if it is moving from one location to another one. The teacher explains network physical layer communications; those advanced electromagnetic lessons give the scientific foundation for wireless communications. Then, physical exchanges of data are filtered by the use of packet analyzer. Practical experiments show that negotiation algorithm can be set between two devices or more in a local area.

B. Tablet role into project option

The project option is a teaching which consists of lectures, meetings and labs: each module provides 36 hours of lectures and meetings, supported by labs and directed further study. There are eight taught modules. Their names belong to the list of courses given in the previous section), four per semester. From the end of the exam period, students will be fully engaged in their summer project, which is equivalent to another four modules.

1) Presentation of the project option:

For the projects, students have the opportunity to engage with: Software Architecture, Complex Networks, Workflow, Business Process and the Internet of Things. They have access to licensed software tools, e.g., Fuse *Enterprise Service Bus* (ESB), Tao ORB, and access to commercial network operating systems.

The project is based on the realization of a distributed project where clients run on mobile devices. This year, the topic of the project is to achieve an application for a telecommunication operator offering its customers access to fixed telephone networks, mobile phone, and Internet (data, image, voices). This telecommunications company operates nationwide through the operation of a full infrastructure: antennas, splitters, hubs, routers, controllers, etc. It also sells or provides to its customer terminal equipment (mobile and fixed phones, box) [see Fig. 1]. It also has monitoring centers, which allows him to oversee all activity on these networks and to intervene in case of failure or degradation of service as well as many administrative and technical departments to ensure all of the services offered to its clients.

The company might be interested in the proposed student project solution if it has the required physical infrastructure, but lacks software coupled with the enterprise information system. The purpose of this project is to create a modern information system for such use. The potential customer has the following objectives:

• Positioning as a major player in the Cloud

• Converging data from different networks are integrating the new mobility

• Access the Cloud in multichannel

• Integrating B-to-B offering a solution tailored to the needs of each

• Ensure the customers the validity of the software solutions through the use of a dynamic environment and equipped simulation.

2) Project functionalities

The project offers subscribers an online portal. As a mobile operator, it offers its customers a mobile application that allows direct access to the functions of the portal, except access to Webmail. One example is consultation mobile account access to invoices. The operator hopes that this

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application remains dedicated to mobile devices. This application must be downloaded from the online portal or from the Android store.

The operator offers online storage space in the cloud. This space is available to subscribers. Subscribers can access their cloud from its private online space, but also on their mobile or tablet. The operator aware that the Web universe differs from mobility wishes clearly separate both activities. With this application, a subscriber can store and share content with other subscribers for free. It can also offer content for download on the user's unsubscribed Internet. Cloud operator is available to non-subscribers via a paid subscription. The subscriber also has the ability to automatically find his bills in the Cloud. This space is read-only, of course.

The operator already has a specialist in the development of access site to the cloud, but the cloud architecture remains to be built. The operator wants to ensure its clients 24/7 access to its data. It communicates on the guarantee of non corrupt and automatically backed up data [12] [13].

The operator can add to its offering software (PC / Mac / Linux) and can automatically synchronize a local folder with the cloud. It complements this offering with an Android app with the same functionality. It adds the ability to synchronize the contacts directory and calendar.

Finally, the operator wishes to develop a business to business service offering its Cloud as a service on demand. The operator has understood that companies can, in turn, develop mobile applications that can access the Cloud. Because access is made by applications and not by users behind a graphical user interface (GUI) online or mobile, it must be controlled. The operator would like to propose a solution built on a scale of subscriptions: 10,000 hits per day for € 50 per month, 100,000 hits per day for € 80 per month, € 0.02 extra access. In order to better control access, the operator provides free tools for the development of third party applications.

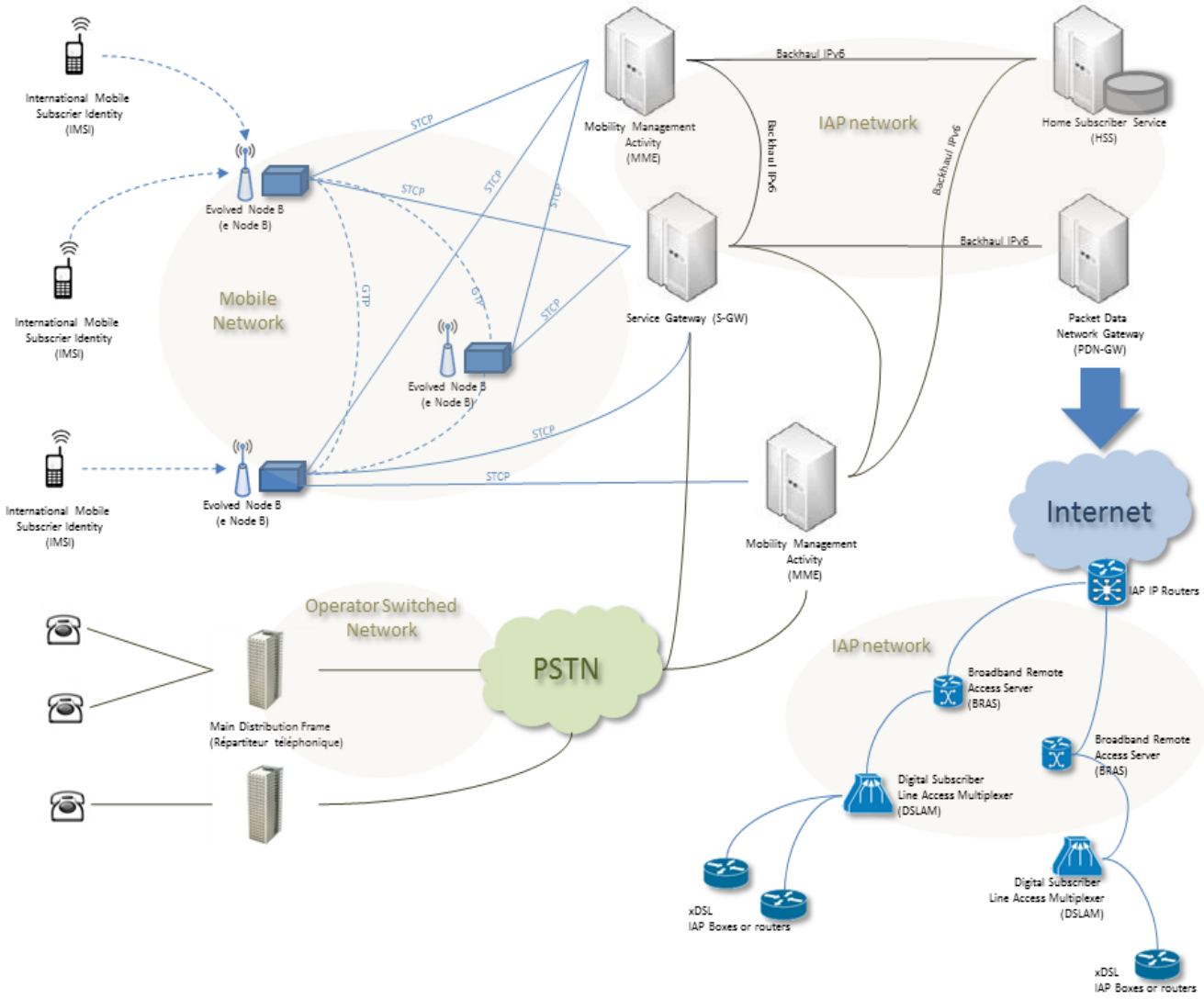

Figure 1. Material architecture of the student project.

As shown in Figure 1, SGW (Serving Gateway) equipment is intended for packet routing between the eNodeB and a data network such as IP network. PDN GW (Packet Data Network Gateway) meanwhile it provides the direct interface between the Long Term Evolution (LTE) network (4G) and the Internet network or Session Initiation Protocol SIP-based networks.

3) Software architecture

Most cut into thirds architectures based on service-oriented backend. These services are masked by the GUI, intermediary services, and online applications. However, these services often have business logic. Access to these services Backend is made possible through the common protocols used in the world of Web: *Simple Object Access Protocol (*SOAP), REST, etc. [11].

Computer Internet or PC (Mac / Linux) differs from mobile computing. The screen size, connectivity, energy saving drives, software to provide dedicated mobile terminal applications. When an application is available online, it is also via a special mobile browser. Airworthiness becomes smaller by the nature of the mobile terminal. That's why publishers often offer a dedicated application. The case is the same for PC applications (Mac / Linux).

The realization of the project is based on object implementation using software architectures known models (design patterns, *model-view-controller (*MVC), DAO, Singleton, Decorator, etc.). The implementations permit to decouple application components to make the technical aspects of modular software. Each program must be delivered manageable. Or it can be configured itself (through its menus, loading options) or through programs (or applications) Administration (configuration).

C. Tablet role in student life

The use of a tablet in school as extra-school is perceived by students as an asset. It is a way to communicate on social networks. It also offers the opportunity to better prepare their future jobs.

In addition, students use mainly for doing all kinds of searches: cinema, show, address, they use it mainly to check their e-mails. Finally, they use it mainly to watch the video and / or listen to music. Some video tutorials are directly related to the project option.

IV. RESULTS OF OUR TEACHING APPROACH

If the touch pads do not replace completely the computers, they enrich the teaching strategies used by teachers and the learning of their students, with shades depending on the levels and objectives. Rapid implementation, autonomy, lightness, ease of use, mobility is known qualities to change the organization and use of digital technology in the classroom. The tablet provides the flexibility of the duration and frequency of sessions. The tablet is on the table, next to the book, the book and the kit can be used at any time for a consultation exercise, a recording, a work of individual or collective research, even for an activity short. It is one tool among others and fits naturally in a conventional teaching session.

This type of tool allows the student to alternate easily between individual work and group work. Individual work produced by the student or by a group of students on a tablet is projected on the board and is subject to analysis, discussion and collective changes. Trade shares, confrontations, conjectures, many processes that facilitate or strongly boost the development activity and student participation. The tablet is the complement of digital interactive whiteboard in digital class. It helps to make a coherent and enhances its effectiveness.

In addition, there are a variety of educational activities related to the specific contributions of the tablet. The multi-sensory aspect makes it a more suitable tool computer to pupils with special educational needs. It allows renewed in disciplines related to the interaction creativity. It changes the status of the writing of the book.

The tablet allows the students to associate reading and writing facilitated by circulating between consultation, comments and exchanges, but also to play with the image and sound - especially for repeat presentation. It facilitates access to multiple resources such as numerous works (simply stored and maintained on the machine or made available from specialized servers). The recording and playback feature makes the tablet a little language laboratory. Cameras and cameras are used in many occasions (during oral expression) to produce reports meeting work. Mobility also opens uses far impossible to consider. It fundamentally changes the attitude and student learning strategy in computer science courses and other disciplines.

V. CONCLUSION AND FUTURE WORK

After a first quarterly study, we are convinced of the value of our teaching approach. We have shown in this paper that the contribution of the tablet is the undeniable motivation of the students but also their investment at work. This is seen especially for the project option which uses the tablet in multiple ways. Finally, the satisfaction of having a specific tool for their training, provide students a motivation of success. We mentioned in our feedback, the role of tablets in the preparation of presentations, analysis workshops.

We intend to continue our approach by exploiting further use beyond tablet. In fact, all teachers do not have sufficient supplies to meet the demands of students. Also, for the next school year, we would to set up dedicated software for the exchange student teachers, based on a multi-channel communication medium. We are currently in the process of defining needs and we are looking forward to prepare for the 2014 school year.

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The Normalization of Mobile Devices in Clinical Nursing Education and in Clinical Practice

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Abstract— **Significant knowledge gaps exist in how students and clinicians recognize the meaning or coherence of using mobile technology in practice, and how they have used this technology to develop communities or learners. In investigating these gaps, our research has looked at various elements including what social or organizational factors influence the normalization of the practice of using mobile technology in clinical education, and as students' transition to licensed clinician. This descriptive research currently in progress uses qualitative and quantitative methods over a six year period (three within nursing education, three as licensed clinicians) to ascertain the confidence of our participants in information and communication technology, usage information, and their views on factors which promote or inhibit successful normalization of mobile technology at the point of care. Preliminary data based on Normalization Process Theory and the Unified Theory of Acceptance and Use of Technology model indicates that mobile technology is being normalized in our students' social realm but hindered in the clinical realm by health care policy and lack of understanding of the affordances available through the technology.**

Keywords- mlearn, UTAUT, nursing education, point of care technology

I. INTRODUCTION

Mobile technology and hand-held communication devices are now a significant part of life for many professionals. They afford both unprecedented communication opportunities (individual, group and mass) anywhere, anytime as creative new services are offered from amateur creators to gigantic corporations. Research about the influence and contribution of mobile communication devices to professional life is still emerging. There is a change to Canadian culture that has presented itself well ahead of our understanding. This is particularly so in relation to the impact mobile devices may have on those who are engaged in formal learning.

Using mobile phones and nursing resource software from an infrastructure grant is allowing us to compare the normalization of mobile enhanced clinical practice across two nursing education practitioner groups: students in a baccalaureate of nursing program, and nurse practitioner students. Specifically, we are examining "How and why things become, or don't become, routine and normal components of everyday work" [1] and to explore of mobile community of inquiry development [2]. Preliminary data indicates that mobile technology is being normalized in our students' social realm but hindered in the clinical realm by health care policy and lack of understanding of the affordances available through this technology. As well, professional and moral issues are surfacing in our preliminary data analysis of the interviews.

Previous research points to the added value of mobile technology in nursing practice education, but demonstrates the need to introduce the technology early in the program and for a sustained period. [2]

Our program of research continues to builds on our previous research and proposes to break new ground in terms of: a) longitudinal studies of participants using mobile learning technologies b) the diverse comparison groups involved, and c) the multi-disciplinary nature of the research team.

This paper will describe our research activities and will lead to a new understanding of the role of m-learning in education. In addition, we will introduce an innovative test of existing theory in distance teaching and learning, the Community of Inquiry model, in a context (mobile learning) different than that for which the theory was initially conceived.

II. RESEARCH TO DATE

Our program of research is currently entering its second phase. In **phase one**, we have used mobile phones and nursing resource software from an infrastructure grant, which

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has allowed us to compare the normalization of mobile enhanced clinical practice across two nursing education practitioner groups, i.e., "How and why things become, or don't become, routine and normal components of everyday work" [1], and to explore of mobile community of inquiry development [2].

There is a plentiful body of knowledge on the perceptions about and ways to use mobile devices in health practice, but there is a dearth of information about the added value if any of using mobile devices in health care education or practice. This study will allow us to "normalize" the use of mobile devices in clinical education through the early receipt of devices and software and the use and encouragement of use over several semesters of clinical use. We expect that students who have used the technology through their entire program will demonstrate that they have "normalized' the technology into their clinical practice leading the way for follow up studies in the working world in the future.

Preliminary data from phase one indicates that mobile technology is being normalized in our students 'social realm but hindered in the clinical realm by health care policy and lack of understanding of the affordances available through the technology. As well, professional and moral issues are surfacing in our interviews.

The **second phase** of the study will allow us examine any changes in use of the technology in the transition from the education setting to the work setting. The graduates/participants are either registered nurses or nurse practitioners in a variety of work environments across the country. Social and policy implications will emerge in the data.

Researchers will benefit from the knowledge of how mobile technology is utilized and normalized in practice; this in turn will potentially positively impact their ability to prepare students for practice. We expect that students who have used the technology through their entire academic program will continue to demonstrate that they are normalizing the technology as they transition into their clinical practice.

The purpose of this research project is to extend the normalization of mobile technology in nursing clinical education to the workplace, after the participants of our concluding project.

III. IMPORTANCE OF RESEARCH

Our program of research builds on our previous research and proposes to break new ground in terms of: a) how long participants using mobile learning technologies will be studied, b) the diverse comparison groups proposed, and c) the multi-disciplinary nature of our research team.

Our research activities will lead to a new understanding of the role of m-learning in education. In addition, these proposed research activities introduce an innovative test of existing theory in distance teaching and learning, the Community of Inquiry model, in a context (mobile learning) different than that for which the theory was initially conceived. Funders continue to invest money into the development of technology, but take for granted the adoption and normalization of this technology in teaching and learning. This is a missing piece in the use of such technology.

IV. CONTEXT

Personal Digital Assistants (PDAs), laptop computers, and MP3 players is now irrefutable [3, 4]. Current mobile technologies - especially third generation (3G) wireless devices such as the Apple iPhone and Google Android cell phone - provide an unprecedented opportunity for inexpensive and beneficial computing power for learners [4, 5]. A recent online poll revealed that seventy per cent of wirelessly connected Canadians are accessing the mobile Internet for personal e-mail and more than one quarter are browsing the web from their mobiles at least once a day. Half of those are accessing popular social networking sites like Facebook and Twitter directly from their mobile devices.

Educational institutions must meet the ever-changing needs of the current and new generations of learners by delivering relevant education anytime, anywhere that also exposes learners to current technologies [6]. It is pertinent to ask why this mobility should not be tapped into to support learning. Keegan [4] has declared that the future of distance education is wireless and claims that the challenge for distance educators is to now develop pedagogical environments for mobile devices.

To answer that challenge, one must first ask what m-learning allows educators to do differently than other forms of teaching and learning. In 2005, Keegan defined m-learning simply as the provision of education and training on PDAs / palmtops / handhelds, smart phones and mobile phones. However, others now see m-learning as more, as the use of information and communication technologies to facilitate learner's mobility in different contexts. Kukulska-Hulme and Traxler [7], for instance, view the most significant attributes of mobile technologies as their ability to support learning that is more situated, experiential and contextualized within specific domains and to support the creation and use of more up-to-date and authentic content. Access to up-to-date information aligns mobile learning with a long standing distance education commitment to improving access to learning opportunities. In addition, mobile learning supports the more recent commitment to interactive, collaborative constructivist learning that distance online education offers [9]. Models of online distance and distributed education offer insight into the potential benefit of mobile devices for learners. The scope and format of mobile learning as well as the technologies and devices utilized in the process are, indeed, context contingent and depend largely on the needs of learners, the unique setting and the available infrastructure [6].

Presently, we are witnessing the advent of the mobile and wireless technology era influencing contemporary businesses and organizations [8]. Mobile technologies have been used broadly across sectors to provide goods and services to consumers and have revolutionized how organizations and individuals go about their daily activities [6]. Mobile devices are significantly changing human–computer interaction, communication, and learning activities. Ubiquitous access to

 ISBN: 978-1-61208-328-5

remote resources is one of the most interesting characteristics achievable by using mobile or handheld devices [10].

Mobile technologies do not offer just another way of doing what is already done, but open up new possibilities in terms of learning and teaching. The m-learning literature focuses on changes in the learning environment, characterized by the pervasiveness and ubiquity of the technology, and on the changing characteristics of higher education students in relation to their use of mobile devices for learning [11]. Few studies have explored the potential of existing infrastructures of personal mobile devices, particularly in settings such as placements where access to a computer may be difficult [12].

Mobile learning takes place when a student uses portable devices, such as smartphones, netbooks or tablets, or handheld gaming devices, to access learning materials and systems, create content and interact with other students, teachers, learning systems and the world around them [13]. Mobile Learning (m-learning) refers to the use of emerging technologies to enhance students' learning experiences. The m-learning literature continues to debate the pervasiveness and ubiquity of mobile devices and their potential use for learning [6, 11, 12, 13, 14].

There is a need to re-conceptualize learning for the mobile age, to recognize the essential role of mobility and communication in the process of learning, and also to indicate the importance of context in establishing meaning, and the transformative effect of digital networks in supporting virtual communities that transcend barriers of age and culture [15] The scope and format of mobile learning as well as the technologies and devices utilized in the process are, indeed, context contingent and depend largely on the needs of learners, the unique setting and the available infrastructure [7]. Learning activities include complex cognitive and social processes that are necessarily to interact with the world around it. M-Learning systems provide opportunities for learners to communicate with the real world and to search interdisciplinary domains [11]. Higher education establishments will need to shift resources and skills in order to fully exploit the potential benefits of mobile technology for learning [12].

Previous research from our university [16, 17] points to the added value of mobile technology in nursing practice education, and demonstrates the need to introduce the technology early in the program, for a sustained period of time. More recently, our research team is concluding a three year research project which has permitted us to engage student nurses (Licensed Practical Nursing-Bachelor of Nursing and Nurse Practitioner) and faculty during the clinical practice education at the undergraduate and graduate level.

"Whilst universities have attempted to integrate information and communication technology into nursing curricula it is not known whether the skills developed for educational purposes are relevant or transferable to clinical contexts" [18]. It is prudent therefore to ascertain the confidence of our graduates in select areas of Information and Communication Technology (ICT) skills.

V. NORMALIZATION PROCESS THORY AND UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY

Our past research identified two major issues that impede the "uptake" or normalization of mobile technology in practice. Those are, the short time frame of the studies and the lack of ownership or lack of "bonding" with the technology. This led us to consider Carl May's [1] Normalization Process Theory (NPT) which describes "the dynamic process of implementation, embedding and integration that run(s) through new ways of thinking, acting and organizing" (p.536). While May identifies the sociological tools that frame the stages of Coherence, Cognitive Participation, Collective Action and Reflective Monitoring, the theory has not been tested in relation to normalizing mobile technology in education.

The NPT model briefly defines these terms as follows: coherence as the meaningful qualities of a practice; b) cognitive participation as the enrollment and engagement of individuals and groups; c) collective action as interaction with already existing practices and; d) reflective monitoring as how a practice is understood and assessed by actors implicated in it [1].

There has also been ongoing research in Information Systems for four decades on how and why people adopt information technology [19]. A recent cumulative model, Unified Theory of Acceptance and Use of Technology (UTAUT) has been used by several research teams to estimate the variance of performance expectancy, effort expectancy, social influence, behavioral intention and facilitating conditions in the prediction of actual use of technology. We believe that the repeated use of the UTAUT scale over time, will measure the movement of nursing students and faculty along the process continuum of normalizing mobile technology into their clinical learning and practice, and again as they transition into novice practice.

VI. DISCUSSION AND FUTURE WORK

The study of the development of mobile communities of inquiry could also prove to be a useful tool as educators consider the effectiveness and quality of emerging education technologies [20]. Our belief that mobile technology will enhance student-faculty, student-student and student-expert communication leads to the concept of mobile, virtual communities or networks of learners and potentially of practicing nurses. This in turn leads us to also consider the application of the Community of Inquiry (CoI) model [20] to m-learning in this context.

The CoI model assumes that learning occurs within the community through the interaction of three core elements: cognitive presence, social presence, and teaching presence. Since the educational experience is a social transaction, special consideration must be given to the social interactions and climate. Teaching presence is defined as the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes [21]. Three elements, design and organization, facilitating discourse and

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direct instruction, make up the central activities of teaching presence.

We are interested in determining in particular how improved communication might help to build and maintain learning community by increasing learners' cognitive presence and teaching presence. As such, we are looking for the direction and structure of the relationship between an online Community of Inquiry and the realities of accessing this community through mobile devices. Can mobile devices be used to generate and/or sustain community?

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Training Science Teachers to Design Inquiry-Based Lesson Plans through a Serious Game

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Abstract— **A significant challenge for science teachers' training is to understand how to enact teaching strategies that would encourage students to perceive learning as a memorable experience instantiated through an activity; and thereby getting involved in a process of meaning-making. This paper describes SimAULA, a serious game that aims to integrate inquiry learning into game dynamics for scaffolding science teachers' efforts to design their lesson plans. To this line, the paper proposes a 7-step process of orchestrating inquiry features that enable science teachers to think about inquiry in the context of creating activities based on real-world situations that map closely on to students' understandings rather than those with naturally occurring complex patterns. SimAULA's overarching architecture is presented in the context of the 7-stage inquiry process to be implemented and evaluated in a number of schools across Europe.**

Keywords: serious games; inqury-based learning; science; teacher training

I. INTRODUCTION

Scant attention has been given in training teachers to prepare lesson plans using a serious game. Although there are some instances where teachers are using digital tools for professional development, these are mainly focused on traditional content-based approaches via the use of an institutional virtual learning environment. The advent of digital games used for education and training, also known as 'serious games', may facilitate teachers on designing, and orchestrating lesson plans and managing the overall classroom environment based on pedagogically-driven strategies.

The movement towards the use of serious games as learning tools in schools is proliferated by the perceived ability of such games to create a memorable and engaging learning experience. Various commentators and practitioners alike argue that serious games may develop and reinforce 21st century skills such as collaboration, problem solving and communication [1]. While in the past, teachers have been reluctant in using serious games for improving their teaching practice, there is an increasing interest, especially in science disciplines, to explore how serious games could be used to improve lesson planning and classroom management [2]. The overarching assumption made is that serious games are built on sound learning principles encompassing teaching approaches that support the design of authentic and situated learning activities in an engaging and immersive way.

Developing serious games based on student-centred pedagogies that enable students to engage actively with questions and problems associated with their subject or discipline is an empowering approach with benefits for subject learning as well as for developing a wide range of important high-order intellectual attributes including the notion of *'transferability*. Inquiry-based learning is perceived as an emerging learning approach for transferring learning in real-worlds situations. It can be seen as a variant of active learning in which students carry-out research like activities to explore and master an existing knowledge-base - and as a tool for developing relevant discipline-based and other transferable capabilities and understandings.

The serious game SimAULA supports the readiness of science teachers to design inquiry-based lesson plans as well as to manage the classroom while engaging in virtual situations. One of the benefits of using SimAULA is that experiences acquired in the virtual environment are transferrable to the real classroom and to new settings and contexts. In addition, the opportunity science teachers have to master the process of lesson planning at their own pace and time supports the development of confidence into the realms of genuine scholarship, positioning them as engaged producers or authors of knowledge with potential to generate original intellectual or creative outcomes. In the following section, the state-of-the-art in serious games design is related to the design of serious games for teacher training, the design of learning activities using the inquiry-based learning approach, and inquiry-based serious games for science education (Section 2) followed by the underpinning inquiry framework developed for the game (Section 3). Then, the paper describes the game's approach and architecture (Section 4) and concludes with a reflection on future plans for uptake and usage across schools in Europe in the forthcoming years (Section 5).

II. BACKROUND

The 2013 NMC Horizon Report [3] asserts the perspective that games are effective tools for increasing student's motivation and engagement by involving them into a memorable learning experience. A serious game can be defined as "a game in which education (in its various forms) is the primary goal, rather than entertainment" [4] p.21. [5] added the element of a *contest* played with a computer in accordance to specific rules. [6] carried out a study to identify the possible relationships between the ability to identify mathematical patterns and the ability to play games

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with certain rules and victory conditions. The study showed that students were able to identify mathematical patterns more effectively by playing a game in comparison to traditional face-to-face teaching practices. Furthermore, concept scaffolding and simulation of real world experiences may be triggered effectively in order to solve problems and enhance student's performance. For example, [7] surveyed 264 students playing an online educational game and found a relationship between rewards and motives. [8] have shown that games can support novel approaches to learning by scaffolding players' experiences in new worlds and learn by trying to solve ill-defined problems inside the game, bringing to the fore the notion of *'learning by doing'*.

In recent years, different aspects of serious games have been widely discussed including their impact and outcomes ([9], [10]), motivating features [11] and in-game learning design [12] led to an assumption that games might provide an environment where learning and teaching becomes engaging, memorable and fun [13]. [14] argued that pedagogically-driven games reflect strong commitment to educational values and have great potential to drive students in achieving intended learning outcomes.

In contrast to the commonly used term *game-based learning,* which predominantly focuses on student motivation, game-design features, learning achievements, learning attitudes and in-game assessment, *game-based teaching* refers to the teacher practices involved in designing, selecting, facilitating and validating the use of games for educational and training purposes [15]. There are a number of inter-related aspects in game-based teaching surrounding teachers' conceptions of, and approaches to, serious games [16]; teacher's role in facilitating learning in the game [17] and the relationship between teacher's approaches of teaching and the learning models applied in games. Identifying the appropriate pedagogical approach and aligning it to an intended learning outcome specified by the teacher may determine what kind of learning processes, scaffolds and activities a particular type of game will afford. Thus, training teachers to adopt pedagogical approaches based on certain learning outcomes that are supported by different types of games will potentially enhance their educational value. From a pragmatist perspective, however, this does not mean that certain pedagogies are more cohesive than others as this always depends on the complex interplay between the learning environment, the level of students and the learning situation the teacher aims to introduce.

A. Games and virtual worlds for teacher training

Using technology, as a training tool is predominant as technology becomes integral in modern workplaces, yet some teachers have shown an unwillingness to adapt their teaching style as many of these teachers are overwhelmed with the plethora of the teaching approaches that could be adopted to support the specific modalities of a digital tool. Current research finds that a popular method of using technology in teacher training is the use of virtual worlds ([18], [19]). A virtual world is a useful tool in education, which provides teacher-students with "lived experiences".

A taxonomy of virtual environments from [20] propose that inclusion and accessibility need to be considered during development, to ensure that no minority group are excluded. The taxonomy further explains that it can be difficult for trainers to oversee educational progress of teacher-students using a virtual world, compared to in-class activities. Suggestions for an environment where trainers can observe and monitor the educational process ought to be considered in future research, to produce simulations that ensure teacher-students are not simply "playing" a game, but scaffold teachers to become engaged into in-game learning activities for extending their subject-content knowledge and projecting the curriculum.

TABLE I. INQUIRY TYPES (ADAPTED FROM [25] NRC 2000)

A. Structured	Strongly teacher-directed. Students follow their teacher's direction in pursuing a scientific investigation to produce some form of prescribed product, e.g. they investigate a question provided by the teacher through procedures that the teacher determines, and receive detailed step-by step instructions for each stage of their investigation.
B. Guided	More loosely scaffolded. Students take some responsibility for establishing the direction and methods of their inquiry. The teacher helps students to develop investigations, for example offering a pool of possible inquiry questions from which students select, and proposing guidelines on methods.
C. Open	Strongly student-directed. Students take the lead in establishing the inquiry question and methods, while benefiting from teacher support. For example, students initiate the inquiry process by generating scientific questions and take their own decisions about the design and conduct of the inquiry and the communication of results.
D. Coupled	A combination of two types of inquiry, for example a guided inquiry phase followed by an open inquiry phase.

B. Inquiry-based learning

'Inquiry' is referred to in the science education literature to designate at least three distinct but interlinked categories of activity: what scientists do (investigating scientific phenomena by using scientific methods in order to explain aspects of the physical world); how students learn (by pursuing scientific questions and engaging in scientific experiments by emulating the practices and processes used by scientists); and, a pedagogy, or teaching strategy, adopted

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by science teachers (designing and facilitating learning activities that allow students to observe, experiment and review what is known in light of evidence) [21]. For the purposes of the SimAULA's educational design, our focus is on inquiry as *an active learning process engaged in by students and modelled on the inquiry practices of professional scientists.*

Inquiry learning science activities encompass a broad spectrum ranging from strongly teacher-directed to strongly student-directed [22]. Since science teachers need to adopt different strategies according to different intended learning outcomes, the needs of students, and the specific circumstances of their own (diverse) science classrooms, understanding different types of inquiry learning and teaching will help them to create learning activities that are appropriate in context. A continuum of types of science inquiry, which we refer to as 'structured', 'guided', and 'open', based on usage in the literature, is often described (e.g., [23]) and is reflected, although not systematically, in the Examples of Teaching and Assessment provided by [24] and illustrated in Table I.

The US National Research Council report on *Inquiry and the National Science Education Standards* proposes a definition of inquiry teaching and learning that brings to the fore "...the abilities of inquiry, emphasizing questions, evidence and explanations within a learning context" [25] p.24. At the centre of its definition are five 'essential features' of classroom inquiry. These five essential features emphasize a process of active engagement in scientific investigation, in which the focus is on students learning through and about scientific inquiry rather than on teachers presenting scientific content knowledge as portrayed in Table II.

TABLE II. FEATURES OF INQUIRY AND THEIR VARIATIONS ([25] NRC 2000, P.29)

Essential Features	More Less	Amount of Learner Self-Direction Amount of Direction from Teacher or Material Variations		Less More
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials or other source	Learner engages in question provided by teacher, materials, or other source
Learner gives priority to evidence in responding to questions.	Learner determines what constitutes evidence and collects it.	Learner directed to collect certain data	Learner given data and asked to analyse	Learner given data and told how to analyse
Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed towards area and sources of scientific knowledge	Learner given possible connections	Learner given all connections
Learner communicates and justifies explanations	Learners forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided with broad guidelines to use to sharpen communication	Learner given steps and procedures for communication.

NRC [25] created these inquiry-based categories and their variations to map the entire spectrum of using inquiry-based learning according to the needs and level of a particular classroom. For example, when the teacher wishes to have control over the inquiry activity, then inquiry design is focused on teacher direction and support. If the teacher decides to allow students to direct the inquiry, then inquiry design becomes more open and student-directed.

C. *Inquiry-based Serious Games for Science*

Designing effective inquiry-based learning activities in serious games have not been evidenced in many serious games. However, there some examples of inquiry-based serious games that have been used particularly in science. For example the North Carolina State University developed the serious game *Crystal Island* that targets science education for eight grade students. The game adopts inquiry-based learning to explore concepts related to microbiology. The learning environment (see Figure 1) is set on a volcanic island where a research centre has been established to study the flora and fauna. The player is free to explore the world, to constitute evidence and collect it, as well as interacting with other characters. As some members of the research team fall ill, the player needs to identify the cause of their illness. The user can perform various scientific investigations including experiments in the laboratory, interacting with other characters, reading virtual books on diseases and collecting data about what poisoned the members of the research team.

Figure 1. The Crystal Island game environment.

Another example of an inquiry-based serious game for science is the *RiggleFish* developed by the UL Lafayette's centre for Innovative Learning and Assessment Technologies. In the game the players take the role of a geneticist tasked to discover a fish species. Players work on a research laboratory to breed a type of RiggleFish that produces Omega X. To accomplish the task, students must determine through scientific investigation and observation the phenotypes and genotypes of fish collected and then breed the fish to obtain the RiggleFish (Figure 2).

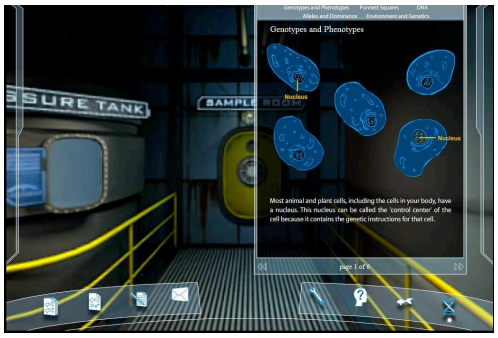

Figure 2. RiggleFish instruments and information resources

Based on a similar game pattern, the *Crazy Plant Shop* serious game help students learn about genes and inheritance. Special order requests from mysterious customers require students to understand dominant and recessive traits and how genetic traits get passed from one generation to the next (Figure 3). The game is designed for science classrooms and being used by students that adopt inquiry learning for investigating how cells grow and their transfer from the parent cells to the offspring.

Figure 3. A mysterious customer enquiring for a mysterioufifs plant

Bringing the pervasiveness and interaction of a Massively Multiplayer Online Game (MMOG) to classroom teaching, MIT developed *The Radix Endeavor* for Science, Technology, Engineering and Math (STEM) in high schools. The game covers topics in biology, statistics, geometry, algebra and probability. The story unfolds on an island with many unknown species and plants waiting to be discovered using inquiry and scientific investigations. The type of game structure has affordances based on inquiry-learning and scientific ways of approaching a phenomenon. Within the game a player can collaborate with other online players for comparing ideas and solve problems, as well as for conducting their own experiments to develop hypothesis while being immersed by the social and contextual elements of the MMO's distinct game-play, mechanics and goals (Figure 4).

Figure 4. The MMO game environment

MMOs seem to be used frequently for promoting social learning and participatory processes between dispersed players around the world. The aim is for different players wih disctinct skills to collaborate together for achieving a common goal.

III. SIMAULA'S INQUIRY MODEL

The NRC features of inquiry (Table II) are essential for driving SimAULA's pedagogical model. Therefore, we have adapted NRC's features of inquiry to match the distinct characteristics of a game-based learning approach encompassing the game mechanics and game play of SimAULA. The adjustments entail some structural considerations as well as the addition of 'Reflection' as a further essential feature. This is consistent with widespread recognition of the importance of student reflection activity in many recent conceptualizations. The Inquiry model is perceived as a cyclical path of the inquiry process where inquiry starts with asking questions and ends with reflection. Each step in the process leads to the next, generating new questions, constituting evidence, analyzing evidence, formulating explanations, connecting explanations, communicating findings and reflecting on the process. (Figure 5). These overarching features of inquiry learning are integrated to the Simulation core of the game and when selected associated inquiry activities will be evoked based on the feature selected. For example, when an activity is associated with the 'Evidence' feature the student might collect evidence through a WebQuest [26] designed by the teacher or student, guided by peers or teacher or fully controlled by the teacher.

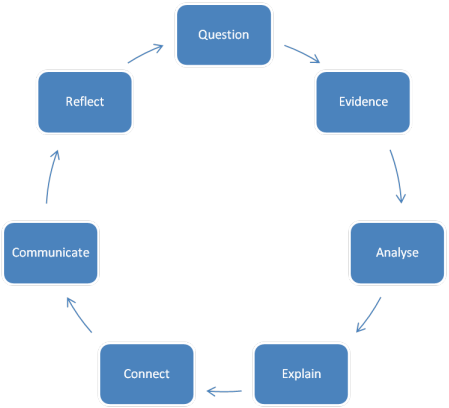

Figure 5. The SimAULA 7-step Inquiry Model

IV. SIMAULA DESCRIPTION AND ARCHITECTURE

SimAULA places a virtual practicum in the form of a three-dimensional world adapted in the context of teaching and learning in schools. Both in-service and pre-service teachers interact with student's avatars and develop lesson plans in the virtual classroom. The teacher develops the role of a science teacher in a biology classroom as an avatar and develops a number of lesson plans for the students. Students are expected to react in different ways as they would do in a traditional classroom. The teacher tests skills and competencies for managing class and enhancing learning. The objective is to accompany the student through the lesson making as well as making appropriate decisions to reach the learning aims. A real teacher controls the teacher avatar while the computer controls the student avatar. The main

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way of communication and interaction is by selecting the options offered by the system. Students are reacting according to the selections the teacher makes, as the objective is to develop and manage the classroom during the lesson and resolve and possible conflicts that may appear.

The design consists of three key sub-components: the Student Model, the Classroom Model and the Pedagogical Model. Inquiry learning will be applied in different types of classrooms, with different ICT and resource availability, and with a different range of learning activities.

The system is divided into two parts. The first part contains the GUI core - the graphical interface which is based on Unity3D, and the second part contains the Simulation Core - hosting the inquiry model. This module is also responsible for driving the simulation. The communication between the two different parts/modules of the system is made through a webservice. The Simulation Core and the GUI core are comunicating via the phases shown in Figure 6. In order to increase interactivity of the game, a number of additional interactive elements are implemented into the game, these include:

- Whiteboard - Users can write on the whiteboard and also watch video footage of various school lessons.
- Computer - The user can use the computers mouse to select icons on the screen.
- Microscope - A microscope slide is shown out of focus, the user must focus the microscope correctly.

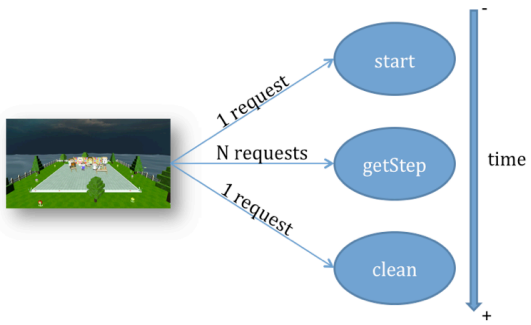

Figure 6. Communication between GUI and Simulation Cores

The teacher is able to configure the desk arrangement in order for students to enact individual, group-based inquiry and whole classroom inquiry activities (see Figure 7).

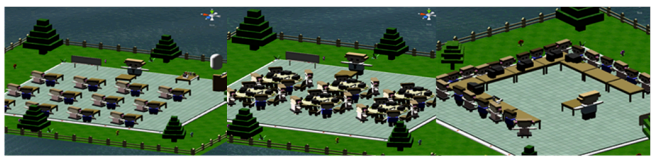

Figure 7. Desk arangement based on individual, group and whole classroom inquiry activities.

The rationale of the simulation is to allow the teacher to vary some attributes and experience how behaviours can vary. But the final goal of the simulation is not to represent in a realistic way the complex interaction taking place in a school classroom. The main learning objective is to foster student teacher's reflection on his/her inquiry choices and to play with different alternatives in a protected virtual environment. Once the user launches the simulation, the simulation requests from the user to select the type of activity from the 7 inquiry features presented in Figure 5. Then, the sequence of activities is provided for a student to decide about how the student will go with the activity (open, structured, and guided) (Figure 8).

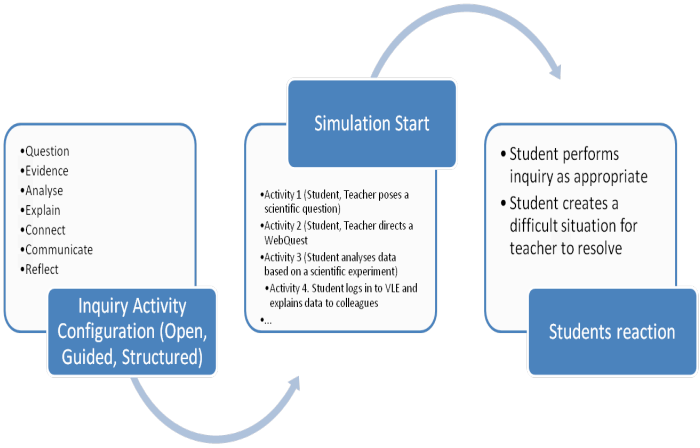

Figure 8. The sequence of SimAULA inquiry process and acitivities taking place in the game

The system is available for PC and MAC and we are currently working on making it available online via Unity Web Player. The system displays the intended learning outcomes related to a specific inquiry activity, it describes the teacher's and student's role (individual and group-based), the tools (e.g. textbook, worksheet, etc) used to implement the activity and type of activity (individual, group-based, whole classroom) (Figure 9).

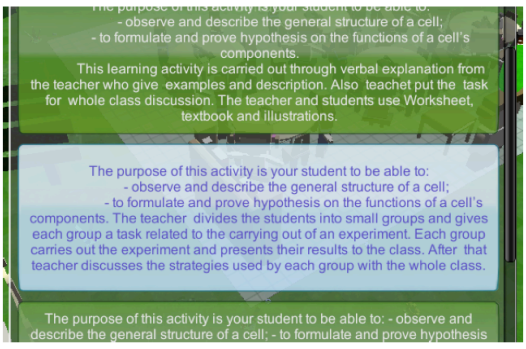

Figure 9. GUI displays the intented learning outcomes, description of teacher and student roles and inquiry activity type.

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V. CONCLUSION AND FUTURE WORK

This paper presented the overarching inquiry-based model used to inform the pedagogical design of SimAULA, the in-game inquiry-process encompassing the associated inquiry activities and student response along with the core game system architecture. Drawing on the wider evidence base, we have identified seven (7) essential inquiry features as elements of effective practice for triggering student's attention, provoke wonder and engagement in scientific activities including asking questions, planning an conducting investigations, drawing conclusions, revising theories, communicating results and reflection.

We are working further on the inquiry-based model to better reflect the associated inquiry activities for each of the different phases. We are also working on highlighting the various inquiry types and their connection to intended learning outcomes and phases of inquiry in the context of the game.

In terms of future research, SimAULA is going to be implemented and evaluated at large scale in Europe in the context of a European project. In congruence with the project objectives, SimAULA is going to be tested in 5,000 schools using a variety of tools for collecting data including surveys, interviews and observations, as means to evaluate the uptake and efficacy in training science teachers to understand inquiry-based lesson planning across Europe, through a game-based intervention, realised over the next 2 years. Testing the proposed inquiry model and aligning it to learning outcomes and assessment is being undertaken through the iterative and participatory design processes within the project.

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A Streamlined Mobile User-Interface for Improved Access to LMS Services

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***Abstract*— Universities in developing countries face greater challenges in implementing Learning Management Systems (LMSs) due to resource-poor settings, characterized by: low levels of ICT infrastructure; electricity outages; few computers; and limited and expensive Internet bandwidth, among other constraints. It is anticipated that if mobile phones are carefully integrated into the ecologies of LMSs, the impact of some of the above challenges in implementing LMSs would be reduced. This paper presents a user-centered design process of mobile LMS interfaces for accessing selected LMS services on mobile phones, and a user experience evaluation for a mobile LMS application implementation. From the design and implementation processes of the mLMS (mobile LMS), and the user experience evaluation of a working mLMS prototype, we conclude that: the ideas presented in the mLMS are technically feasible; the application is useful to the students and the students are encouraged to use their mobile phones to access LMS services more often, thereby reducing the over-reliance and pressure on the constrained institutional ICT resources.**

Keywords-Learning Management Systems; Developing Countries; Mobile Phones; Mobile interfaces; User-centered Design

I. INTRODUCTION

As universities strive to satisfy their students and the students' needs, they are facing competition at different levels ranging from local to global [1][2]. In a globally-competitive educational system, innovative universities that promote a culture of change and are willing to adopt new technologies for enhancing the students' learning experiences stand a better chance of staying relevant and thriving in the new knowledge age [3][4]. Information and Communication Technology (ICT) has proved to be an essential component of the educational system. It has positively impacted the educational system and has played an important role in meeting challenges ranging from educational and administrative to supportive [5].

The application of ICT to support (or enhance) teaching and learning is commonly referred to as electronic learning or e-learning. E-learning covers a spectrum of activities from supported learning to blended learning and to learning that is delivered entirely online. According to Akeroyd [6] and Kakasevski [7], among the various ICT tools that can be used to implement e-learning, Learning Management Systems (LMSs) are the most widely used tools for the support of blended learning and learning that is entirely delivered online. Paulsen [8] also argues that much of the success of e-learning can be attributed to the availability of learning management systems. He further states that the majority of European institutions have extensively implemented and benefited from e-learning via LMSs. The success of LMSs in European institutions has been attributed to Internet penetration as well as a well-developed ICT infrastructure.

In developing countries, however, the potential of LMSs has not been fully exploited, mainly due to resource-poor settings characterized by low levels of ICT infrastructure, among other constraints [9].

Current literature reveals that although universities in developing countries have continued to increasingly invest in the LMSs [10][11], the LMSs have not been fully exploited by the majority of the universities implementing them. To a larger extent, most LMS-supported e-learning initiatives, particularly in developing countries, have not fulfilled their potential. Prior work by the authors [9] and Sife [12] identified various factors that are responsible for the limited success of e-learning initiatives in general, and LMSs in particular, in developing countries. These included: limited ICT infrastructure such as LANs; few computers; limited and expensive Internet bandwidth; power outages; high ICT-illiteracy rates and low comfort levels using ICT–solutions among the students; LMS usability issues; ineffective maintenance and inefficient user support strategies; high expectations from the institutions and their clients, the students; and poor marketing strategies . The studies [9][12] conclude that if learning management systems were to be implemented more effectively in developing countries to support students' learning and to justify the high investment costs incurred by the universities in setting them up and maintaining them, further research and development efforts should be aimed at identifying strategies of reducing (or overcoming) the impact of the above challenges.

In a related study [13], which was carried out to identify possible intervention(s) that could be instigated to reduce the impact of some of the challenges identified, it was noted that the proliferation of mobile phones among university students in the developing countries presents an opportunity to think of alternative ways of making LMS services effectively available to the students via their mobile phones. If this is achieved, it would reduce the over-reliance and the pressure on the institutional ICT resources for accessing the LMS services all the time by the students. After all, Minovic [14] noted that mobile devices have the potential to be integrated into the classroom because they contain unique characteristics such as: portability, social interactivity, context sensitivity, connectivity and individuality. The study [13] revealed that the majority (over 99%) of the

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students in the surveyed universities possessed mobile phones, of which over 70% were Internet (feature) phones and 58% were smart phones. However, the students never used their mobile phones to access the LMS services. They reported that mobile phones presented usability and compatibility problems in trying to use them to access the LMS services. The constraints of using mobile phones to access full websites meant for desktop and laptop computers has also been clearly documented in the literature [15][16][17].

Thus, if mobile phones are to be effectively integrated into the LMS ecology to support students in accessing LMS services, directed/tailored mobile LMS interfaces have to be designed, and here is where the work of this paper seeks to make a contribution. The paper presents: a user-centered design process of mobile LMS interfaces for accessing selected LMS services on mobile phones; the technologies for developing the mLMS application; and the implementation and user-experience evaluation of the mLMS application.

The next section of this paper presents the literature associated with the increased adoption and use of LMSs by Universities and the accessibility of LMS services by the students. The need to enhance accessibility of LMSs for the users (the students) who are constrained by poor ICT infrastructure is also presented in literature review. Then, the design of the LMS mobile interface is presented, followed by the development of the mVula application. Next, we present the evaluation of the mVula application through standard usability evaluation procedures that included: expert evaluation; focus group evaluation and user experience evaluation, followed by a presentation and analysis of the evaluation results. Finally, we conclude with the major findings of this research on optimizing LMS interfaces for mobile access, and the future work.

II. RELATED LITERATURE

A. *LMS Adoption*

Learning management systems, sometimes referred to as Virtual Learning Environments (VLE), Course Management Systems (CMSs), Learning Content Management Systems (LCMSs), Managed Learning Environment (MLE), Learning Support Systems (LSSs) or Learning Platforms (LPs), can be defined as Web-based software application platforms that use Web technologies and Internet services to support: online course creation, maintenance and delivery; student enrolment and management; education administration and student performance reporting [18][19]. The LMSs and related technologies such as the Internet have provided new directions in teaching and learning, and have had a significant impact on the ways in which universities and teachers interact with students. For example, LMSs allow learners to use interactive features such as threaded discussions, chatrooms, discussion fora and other methods of communication among them, with the teachers, and with the university. As a result, LMSs have been widely adopted by universities. In fact, it is difficult to identify many universities that do not use a learning management system of some sort [10].

The increased adoption of learning management systems by universities is premised on the fact that the LMSs are: domain independent; have better administration capabilities; integrated authoring tools; and support the design and publication of reusable learning resources [7][10]. They are thus regarded as the most basic and reliable e-learning tools in blended learning environments, and they are often viewed as the starting point of any Web-based learning program [10]. Furthermore, the emergence of open source platforms such as Moodle and Sakai has encouraged universities, particularly those working with limited budgets, to adopt the LMSs [20], mainly for two reasons: scalability, because the open source platforms allow the universities to have as many users as they like without incurring bigger license fees, given that they are operating under tight budget constraints; and flexibility, because the universities can choose to develop/tailor the open source platforms to meet their particular needs [21].

B. *Accessibility of LMS Services*

Accessibility can be defined as the ability of the Learning Objects (LO) to be accessed by learners in any location regardless of the learner experience, device or the type of platform the learner uses [22][23]. Learning Objects are units of instructional content that can be used and reused on Web-based e-learning systems In LMSs, Learning Objects are presented in the various service components such as: announcements, assignments, resources, forums, chat rooms, course outlines and wikis [24]. According to Ardito [25], Costabile [26] and Wong [27], accessibility of the learning objects plays a significant role towards the success of any online learning programme. Yet Leal and Queiros [24] contend that despite the success in the promotion of the standardization of e-learning systems, usability and accessibility are still a major user concern with the existing systems.

Earlier work by Leal [24] and Dagger [18] claims that adapting Service Oriented Architectures (SOA) to e-learning systems so as to provide flexible learning environments for learners could improve the usability and accessibility of the services. After all, the current generation of LMSs embraced the “services” principle, exposing certain aspects of their functionality externally [11][18]. This means that as designs became more modularized, it is easier for platforms to integrate new functionality as it arises [13]. Furthermore, Dagger [26] argues that the LMS community has made an increased move towards separating content from tools, and the learner information has become more distinguished. However, these systems aren’t entirely learner-centric; they still focus strongly on learning administration (course management) rather than on the learner [18].

The work presented in this paper, however, distinct from prior research, in that the main goal was to enhance accessibility from the point of view of LMS users (the students) who are constrained by poor ICT infrastructure, rather than improving or extending the functionality of LMSs. Similar studies on LMS accessibility were carried

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out within the framework of the European Commission Web-edu project by Paulsen [8] on the accessibility and satisfaction of LMSs in 113 institutions across 17 European countries. The studies revealed no major technical problems with LMSs, and the users rated accessibility to the LMS services as satisfactory. The studies also noted that in the European Nordic region and North Western Europe where Internet penetration was high, it is not easy to find a university without experiences of LMSs, compared to the Southern European region, where Internet penetration was low. The study concludes that Internet penetration determines the level of use of LMSs.

In developing countries, besides the low Internet penetration, there are other constraints such as power outages and the physical infrastructure such as the local area networks and the lack of enough computers for the learner community. These constraints make it harder for the students to access the LMS services. However, the proliferation of mobile phones in the developing countries has to some extent made up for the generally poor physical ICT infrastructure. In this study, mobile phone were integrated into the LMS ecology by designing and developing streamlined mobile LMS interfaces to enhance the accessibility of LMS services through the mobile phones and increase the LMS usage by the students.

III. DESIGN OF THE MOBILE LMS

Overall, a User-Centred Design (UCD) approach was taken. Winograd [28] defines user-centred design as an approach to software design that grounds the process in information about the users of the software product. It focuses on users through the analysis, design, implementation and evaluation of the product. Its aim is to develop applications and systems that are usable and meet the requirements of the users in their context of use [19]. The approach incorporates three principles: involve users and gives them high priority; use rapid prototyping in the design phase to produce a number of prototypes that can be revised through user feedback [29]; and, thirdly, the approach is incremental throughout the whole process, because a number of revisions are necessary to improve the quality of the application through a continuous cycle of gradual refinement [19].

The design of the mobile LMS interfaces was done through a participatory design process [16] with students at the University of Cape Town. At the University of Cape Town, the Sakai LMS is used, and it is locally branded 'Vula'. During the design process, the term mobile Vula (mVula) was used, instead of mobile LMS.

The students who participated in the design process of mVula were randomly selected and, meetings with them were organised in focus groups of 2s and 3s. A total of 13 students participated. The idea of optimising Vula for mobile access by providing access to a few selected Vula services was introduced to the students (in focus groups). To some students, it was a completely novel idea, while others were aware of the presence of a mobile version of the Vula site but had not accessed it. Some had accessed the mobile version of Vula, which they said was not very different from the full desktop Vula site and was not so appealing on the small phone screen. During the discussions (semi-structured interviews) with the students (which lasted 10-15 minutes) some interesting ideas about their expectations for mobile Vula came up, and these were noted by the investigator. The students were then engaged in a co-design session. They were provided with pencil and paper and asked to draw storyboard sketches of what they wanted the mVula interfaces for the selected services to look like. At first, this did not work out well, as most students did not know how to represent mobile phone interfaces on paper, and those who had an idea also wasted a lot of time drawing pictures of full mobile phones (screen, buttons, keypads etc) other than sketching the interfaces.

To provide a hint to novices, and to avoid wasting time in drawing mobile phone pictures, familiar mobile phone screen templates (Figure 1) were printed and given to the participants instead of the plain paper, such that they could now draw the interfaces within the templates.

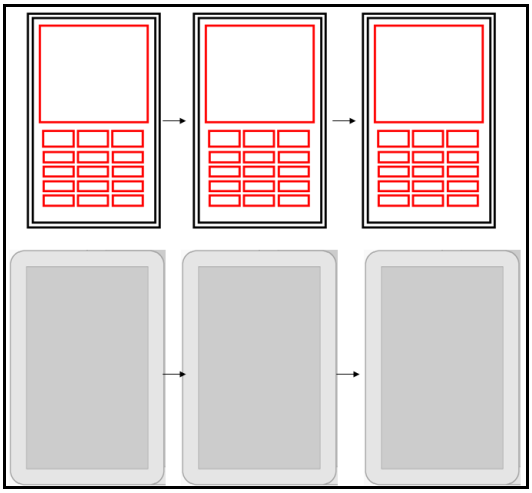

Figure 1. Templates of mobile phone screens

This improved the process greatly and meaningful storyboard sketches were drawn by the students.

From the storyboard interface sketches drawn by the students using the templates in Figure 1 above, the investigator created the first paper prototypes of mVula interfaces, with two distinct ideas: (i) course-based (Figure 2) and (ii) service-based (Figure 3).

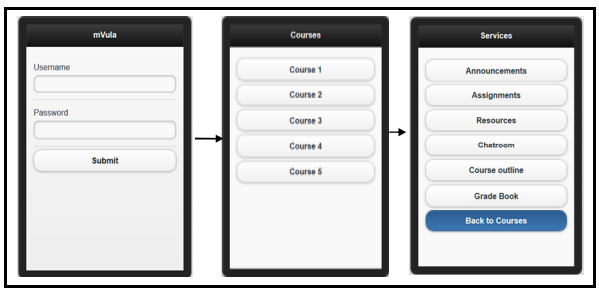

Figure 2. Paper Prototype 1a: Course-based interface

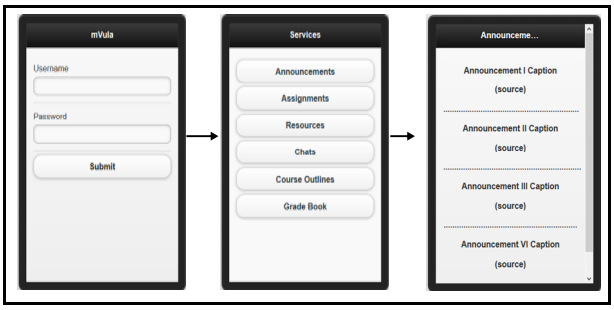

Figure 3. Paper Prototype 1b: Service-based interface

Both of the prototypes (Figures 2 and 3) were given to students to be validated and to choose the most appropriate and appealing prototype to them. Ten students participated in this validation exercise. Eight out of the ten students selected the service-based prototype (Figure 3) and, in addition, they suggested that the services be block-based instead of the tabs. Then, the final paper prototype of mVula (Figure 4) was generated.

The main features presented in mobile Vula include: the application should be service-based (as opposed to course-based); to provide a few services with only the necessary details for each service (defer access to more details through more appropriate devices like PCs); the services to be block-based (as opposed to tabs); services like announcements to be populated with information from across the various courses, and presented according to date.

The most needed/required LMS services to be provided for access on the mobile phones have to be identified and, these may differ from university to university. In the surveyed universities, the most needed/required LMS services included: announcements, assignments, resources, course outlines and chat rooms [13].

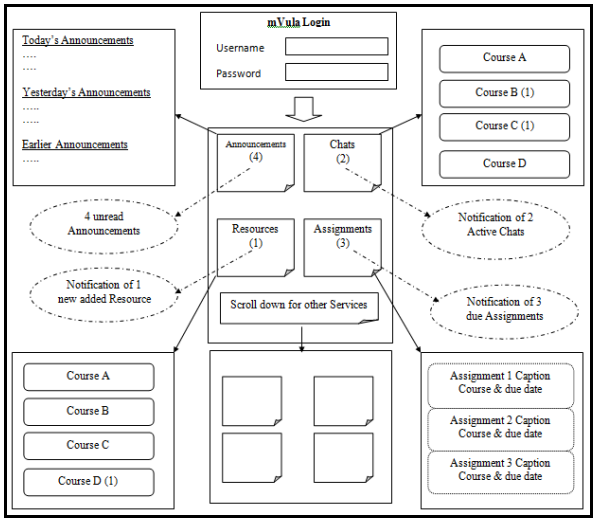

Figure 4. Final paper prototype of mVula interfaces

IV. DEVELOPMENT OF MVULA APPLICATION

After generating the final paper prototype of mVula through the participatory design process, the next step was then to develop a working prototype of mVula, bearing in mind that the users (students) possessed different mobile handsets with differing operating systems/platforms such as Android, iOS, Nokia Symbian, BlackBerry and Windows OS.

As literature on mobile application development highlights [17], there were two ways to develop the mVula application: either (i) to develop mVula for a single mobile platform (native application) and test the ideas on that one platform; or (ii) develop a cross-platform application [30] and test the ideas across all the major platforms.

While the native application option would be easier and more straight-forward in terms of development [31], such an application would be restrictive. Only students with mobile phones with a particular platform would be able to use it. To obtain feedback (about the ideas presented in mVula) from as many users as possible using a wide range of mobile phones, possibly with different platforms, would require development of mVula as a native application for each platform separately. This would require a lot of time; also, it would be difficult to implement and maintain several native applications.

mVula was thus developed as a cross-platform application so as to capture as many users as possible across the major platforms. However, this also presented a different set of challenges, such as the limited number of technologies available to develop cross-platform applications, and the fact that such an application would not be able to utilise some smart phone features that could possibly be required.

In the recent past, the smart phone industry has experienced a major development that has seen most of the current generation of smart phones built with a compatible underlying browser engine, called Webkit [15]. Webkit is an open source library that renders HTML. It eliminates the incompatibilities among mobile browsers, making it easier to develop cross-platform Web applications. This means that any WebApp developed with Webkit support would easily be rendered by the native browsers of most smart phones.

Additionally, there are Cross-platform Mobile Development tools (XMTs) (examples in Table1), that can be used to create apps for different smart phone platforms from the same code base [32][30]. This development does not only reduce the coding load, but also ensures that the services provided through such an application would reach a wider audience of potential users [33].

However, although mobile Web applications do not make any explicit assumptions about features of the delivery context, best practices assume devices with support for standard Extensible HyperText Markup Language (XHTML), JavaScript and Cascading Style Sheets (CSS) capability (W3C n.d). Thus, cross-platform mobile

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applications are typically Web applications. The World Wide Web Consortium has defined Web application as a term that refers to a Web page (XHTML or a variant thereof + CSS) or collection of Web pages delivered over Hypertext Transfer Protocol (HTTP) that use server-side or client-side processing (e.g., JavaScript) to provide an "application-like" experience within a Web browser. Table 1 below shows some of the cross-platform mobile application development tools, and the mobile platforms each supports, as of April 2013; the situation is dynamic, and could change (or have changed).

TABLE 1: SOME OF THE CROSS-PLATFORM MOBILE APPLICATIONS DEVELOPMENT TOOLS (XMT)

XMT	Android	Bada	BlackBerry	iOS	MeeGo	Symbian	webOS	WP7	MinMob
Application Craft	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flash Builder	✓			✓		✓		✓	✓
Illumination Software Creator	✓			✓					
jQuery	✓	✓	✓	✓	✓	✓	✓	✓	✓
LiveCode	✓			✓		✓			
Marmalade	✓	✓	✓	✓	✓	✓	✓		
MonoCross	✓	✓	✓	✓	✓	✓	✓		✓
MoSync	✓		✓	✓		✓			✓
OpenPlug Studio	✓		✓	✓		✓			✓
PhoneGap	✓	✓	✓	✓		✓	✓	✓	✓
Rhodes	✓		✓	✓		✓		✓	✓
RhoStudio	✓		✓	✓		✓		✓	✓
Titanium	✓			✓					✓
XUI	✓	✓	✓	✓	✓	✓	✓	✓	✓
Zepto	✓	✓	✓	✓	✓	✓	✓		✓

Source: Ohrt, [34], plus the individual sites of the presented tools

TABLE 2: SUPPORTING PROGRAMMING LANGUAGES FOR SOME XMTS

XMT	Programming Language
Application Craft	JavaScript, HTML, CSS, Visual Editor
Flash Builder	ActionScript and MXML
Illumination Software Creator	None (drag-and-drop)
jQuery	JavaScript, HTML, CSS
LiveCode	Livecode
Marmalade	C++
MonoCross	C#
MoSync	C++
OpenPlug Studio	ActionScript and MXML
PhoneGap	HTML and JavaScript
Rhodes	JavaScript, HTML, CSS, Ruby
RhoStudio	Ruby
Titanium	JavaScript
XUI	JavaScript, HTML, CSS
Zepto	JavaScript, HTML, CSS, Visual Editor

Source: Ohrt [34] and http://www.markus-falk.com/mobile-frameworks-comparison-chart/

Although Table 1 does not show an exhaustive list of cross-platform mobile application development tools, all the tools presented support Android and iOS, while BlackBerry, Symbian and WinMob are also well supported.

In this case, the tools that support most or all of the major mobile platforms were considered for selection for the development of mVula. However, as already noted, HTML and JavaScript are a prerequisite for Webkit-based applications. Therefore, choice of the final XMT for the development of mVula also depended on the tool's supporting programming languages (Table 2).

From Tables 1 and 2, it is clear that Application Craft and jQuery were the strongest candidates for choice. Finally, as Ohrt [34] argues that the option of using a familiar tool can be a strong incentive to select a certain XMT, jQuery was chosen for the development of mVula.

V. EVALUATION OF MVULA

The first working prototype of mVula was evaluated for usability through standard usability evaluation procedures, complemented with case-specific measures. According to Ardito [25], the ISO 9241 [35] defines usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. The application

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was evaluated for usability at three levels: expert evaluation; focus group evaluation and user experience evaluation.

The expert (heuristic) evaluation [36] was aimed at evaluating the application for: simplicity; errors; efficiency and comprehensibility as well as identifying any Human Computer Interaction (HCI) related concerns and interface flaws to improve user interaction. This was achieved with five HCI practitioners who interacted with the application in a laboratory setting and provided feedback to the developer. The feedback was then used to improve the application before the focus group evaluation.

The focus groups were made up of students who were randomly recruited through a research assistant. The research assistant was asked to identify any students who had smart phones and introduced them to the investigator for further briefing about the exercise. This evaluation was aimed at measuring learnability (ease of use) of the application as well as identifying any functional errors and flaws within the application. Learnability was assessed with two measurements: (i) the ability to use the application without instructions/guidance on the first try, and (ii) task completion without errors or getting frustrated. Feedback was obtained through observations and verbal feedback, as well as a structured questionnaire that the students were requested to fill at the end of the exercise.

With feedback from the experts and focus group evaluations, the application was improved to generate a second prototype (Screenshots in Figure 5).

Figure 5: Screenshots of the interfaces of the working prototype of mVula

The second prototype of the application was then rolled out to students for a user experience evaluation. ISO FDIS 9241-210 defines user experience as: "A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service", and can be measured during or after use of the product, system or service [37]

The user experience evaluation of the mVula application was done with students from the Department of Computer Science, University of Cape Town. Through mVula, the students could access the selected Vula services through their mobile phones, upon login using their University login credentials. The application was hosted on a publically-accessible server, and its address was given to the students. Following a call for participation in this, seventy (70) students volunteered to participate. The students were asked to voluntarily use the application in accessing Vula services for about 2-3 weeks and thereafter provide feedback about the ideas presented in the application, its usability and usefulness. Within the application, there was a link to an online questionnaire (survey tool) that the students had to use for evaluating the application.

VI. EVALUATION RESULTS

Feedback from the user experience evaluation was obtained through an online questionnaire. The questionnaire had two sections. Section one required the users to evaluate the application in terms of ease of use, perceived usefulness and overall satisfaction with the ideas presented in the application. These were probed through Likert-type questions. Section two was the narrative section, which required the users to comment on the application as well as define/mention any other requirements that would make the application more useful to them. Out of seventy (70) evaluation requests that were sent out to the participants, thirty (30) valid responses were obtained, representing a response rate of 44%.

The analysis of the collected data has been divided into two: the Likert–type responses that have been analyzed as ordinal data, and the narrative section that has been organized thematically.

A. *Analysis of the Likert-type Responses*

Likert data can either be of Likert-type or Likert-scale. Clason and Dormody [38] described Likert-type items as the form of the original Likert (Likert 1932) response alternatives that are considered and analysed as individual questions (not summated). In the Likert-type, multiple questions may be used in a research instrument, but the responses from the items may not be combined into a composite scale [39]. That is, Likert-type questions are unique and stand-alone.

In this study, Likert-type questions with five response alternatives (e.g., strongly agree, agree, neutral, disagree and strongly disagree) were used to assess the students' level of satisfaction with the ideas presented in the application as well as to evaluate the application in terms of ease of use

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and perceived usefulness. Several similar mobile application studies have deployed this evaluation technique [40][41]. However, because Likert-type responses express "a greater than" relationship without indicating by how much, the analysis of such data is often limited to ordinal procedures [39].

Methodological and statistical texts recommend that, for ordinal data, one should employ the median or mode as the measure of central tendency, and frequencies (or percentages) as the measure of variability [39][42][43][44]. This is because the arithmetic manipulations required for calculating the mean, standard deviation and some parametric tests are inappropriate for ordinal data, where the numbers generally represent verbal statements [42].

1) *Ease of Use and Perceived Usefulness of mVula*

To assess the ease of use and perceived usefulness of the mVula application, seven questions were asked. Table 3 below presents the responses from the students.

TABLE 3. LIKERT-TYPE RESPONSES ON THE EASE-OF-USE AND PERCEIVED USEFULNESS OF THE MVULA APPLICATION

	Questions		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
1	*Interaction with mVula is clear and understandable*		33.3% (n=10)	36.7% (n=11)	20.0% (n=6)	6.7% (n=2)	3.3% (n=1)	n=30
2	*mVula Application is:*	Easy to use	60.0%(n=18)	33.3%(n=10)	6.7% (n=2)	0.0%(n=0)	0.0%(n=0)	n=30
		Navigable	50.0%(n=15)	30.0%(n=9)	13.3%(n=4)	6.7%(n=2)	0.0%(n=0)	n=30
		Intuitive	23.3% (n=7)	46.7%(n=1)	30.0%(n=9)	0.0%(n=0)	0.0%(n=0)	n=30
		Attractive	10.0% (n=3)	26.7%(n=8)	33.3%(n=10)	26.7%(n=8)	3.3%(n=1)	n=30
3	*I find it useful to use my mobile phone to access some services of Vula*		60.0% (n=18)	33.3% (n=10)	3.3% n=1)	3.3% (n=1)	0.0% (n=0)	n=30
4	*These mVula features make it easier to access Vula via a mobile phone*	Having only a few options/services.	36.7% (n=11)	36.7% (n=11)	16.7% (n=5)	6.7% (n=2)	3.3% (n=1)	n=30
		Using block-based interfaces for the services.	30.0% (n=9)	33.3% (n=10)	36.7% (n=11)	0.0% (n=0)	0.0% (n=0)	n=30
		Merging Information from across courses.	50.0% (n=15)	26.7% (n=8)	13.3% (n=4)	0.0% (n=0)	0.0% (n=0)	n=30
5	*mVula influences me to access Vula more often*		23.3% (n=7)	50.0% (n=15)	23.3% (n=7)	3.3% (n=1)	0.0% (n=0)	n=30
6	*mVula enhances my learning effectiveness:*	in class	16.7% (n=5)	33.3% (n=10)	46.7% (n=14)	3.3% (n=1)	0.0% (n=0)	n=30
		outside class	30.0% (n=9)	40.0% (n=12)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30
7	*mVula saves me the need for a computer all the time I need to access information on Vula*		43.3% (n=13)	43.3% (n=13)	6.7% (n=2)	6.7% (n=2)	0.0% (n=0)	n=30

From Table 3, question one was intended to find out whether the ideas presented in the mVula application were clear to the students. The question was well understood by the respondents and 70% affirmed the clarity of the ideas. Question two evaluated four usability aspects of the application. The responses indicated that although over 80% of students agree that the application is navigable and easy to use, 60% indicated that the attractiveness of the application can be improved. Over 90% of the respondents indicated that the idea of accessing Vula services through streamlined mobile interfaces was very useful. The students were able to get the information they needed from Vula via mVula without the need for full desktop interfaces.

Question four was intended to evaluate the perceptions of the students about some of the ideas presented in the mVula application. While over 60% of the respondents agreed that the features of mVula make Vula services easier to access on the mobile phone, they also suggested more features.

The question about the effectiveness of the mVula application registered the highest percentage of neutral responses. This was probably because the respondents were not in position to judge the effectiveness of the intervention within a period of three weeks. This attribute of the study will be assessed further in a longitudinal impact evaluation that will be carried out in subsequent studies.

2) *Overall Satisfaction*

The overall satisfaction with the ideas presented in the mVula application was probed through a five-point Likert-scale (Table 4).

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TABLE 4. OVERALL SATISFACTION OF THE IDEALS PRESENTED IN MVULA APPLICATION

Question	Highly Satisfied	Satisfied	Partially Satisfied	Not Satisfied	Not at all Satisfied	Total
What is your overall satisfaction with the ideas presented in mVula?	26.7% (n=8)	43.3% (n=13)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30

Although none of the respondents was "not satisfied", almost a third of the respondents (30%) were partially satisfied. Therefore, this means that more work had to be done on mVula to create greater satisfaction. By incorporating some of the comments provided by the respondents, it is hoped that the satisfaction level will increase.

B. *Comment Analysis*

The feedback from the narrative section of the questionnaire was analysed with the following as guiding questions:

- What additional requirements are defined by the users?
- What improvements in the prototype should be made to enhance user satisfaction of the application?
    - What is the problem with the prototype and what is the scope and severity of the problem?
    - What solutions can be implemented across the platforms and which ones require native applications?

1) *Additional requirements defined by the users*

a) More services, such as Tutorial signups, Grade book and Tests & Quizzes, were requested for in the application by some students. However, the original idea of the application was to provide a few services, given the limitation of the mobile phone. Eight services were provided, and these had been identified as the most needed/required services. These services can differ from university to university and can easily be changed from time to time. In this case, however, the chosen services will be maintained.

b) Enable assignment submission using the phone. Some students requested that the application should allow them to make submissions, especially assignments. This can possibly be implemented across the platforms. However, the students will still be advised that the use of the mobile phones to access LMS services cannot be used as a surrogate for computers, so to perform some tasks such as attaching and sending files would better be done using more appropriate devices, such as PCs and laptop computers.

c) Notifications for new announcements and reminders for assignment deadlines. The notification function could not be implemented across platforms. It required the use of smart phone features that are supported differently for each platform. To test the feasibility of this ideal, however, an Android notification service was developed and has been integrated into the mVula application.

The service connects to the LMS server and runs in the background of the phone and notifies the user of any new announcement posted.

2) *Required Improvements*

a) Given that the application pulled all the announcements from across all the courses and presented them according to date, the students said that it was difficult for them to determine which announcement is for which course by simply looking at the announcement caption. So, they required that the source of the announcement be indicated as part of the announcement caption. The same also applied to the assignments. This has been implemented and works across all platforms. The captions of the announcements and assignments are displayed with title and source (course), and are arranged according to date.

b) Most current courses should be displayed first (or courses should be ranked on the screen according to the users' preference.). This has been implemented. The priority in course listing is according to the date of course registration. That is, the current semester courses are listed first, and then the older/previously registered courses follow.

c) Some students felt that the colours used and the overall visual appeal of the interfaces was quite dull, and buttons seemed too big to fit on some screens. Best practices of visual presentations have been consulted and the colour scheme improved.

Overall, there were no major problems with the prototype. There were more positive comments from the students, most of whom seemed happy to use the application in the current state.

Most of the additional requirements raised by the students could be implemented on Webkit (across the major mobile platforms), except one: the notification service which required native services for each platform. The additional requirements that could be implemented on Webkit have been implemented, and a native service to pop up notifications of new postings in Vula has been created for the Android platform and integrated into mVula.

VII. CONCLUSION AND FUTURE WORK

Understanding students' expectations for a mobile LMS, and involving the students in the design process of the mobile LMS interfaces is key to designing and developing usable mobile interfaces for accessing LMS services. The students prefer: to go through less "clicks" before they can be able to access the desired LMS information; that access

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of LMS through the mobile phones should be service-based, as opposed to course-based; that the mobile LMS application should be made as simple as possible and non-crowded, that is, fewer LMS services (the most needed/desired services) should be made accessible through mobile phones.

Some of the students who participated in this study (and possibly the majority of students in developing country universities) exhibited behaviors that we had not seen previously reported in the literature in the use (and ability) of their smart mobile phones. This may be symptomatic of technology "leap frogging," where the new internet users among the students are obtaining access by mobile devices and are skipping the traditional means of access. This has to be taken into consideration when involving such users in the design process of streamlined (directed/customized) interfaces. For instance, in our case, some students did not know what to expect in streamlined mobile interfaces for an LMS, and how different such interfaces could be from the full LMS interfaces meant for computer access. The fact that we had to prepare and use mobile screens templates instead of plain paper during the co-design sessions with the students to generate paper prototypes may also indicate a lack of clarity in the difference in the roles between mutable software and immutable hardware.

Through the participatory design process with the students, we created a paper prototype, and then a working Webkit-based prototype for mobile Vula (mVula) to test the ideas of a mobile LMS. From the design and implementation processes of mVula, it has been demonstrated that mobile interfaces for LMSs can be made more usable and useful by selecting an appropriate subset of services. The user experience evaluation of the application also indicated that the idea of accessing Vula services through streamlined mobile interfaces was very useful to the students. Actually, the streamlined mobile interface encourages greater use of LMSs and allows students to get the information they need without the need for a full desktop interface.

However, during the user experience evaluation, the students also defined additional requirements, most of which have been implemented to further better the usability and usefulness of the application. In future, we will deploy the application for a longitudinal user experience evaluation to assess its overall value–impact evaluation.

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Analysis of Blended Classes on Operations Research Focusing on Practice

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Abstract— **Operations Research classes are held focusing on practice. Following the textbook, slides are shown, there are lectures on problems and their formularization and solutions are explained using examples. After classes, as practice, a sheet with blank boxes for answers to similar problems in the same format as the examples was distributed and students were asked to complete it. The next week, after giving the answers to the practice problems, a sheet with problems similar to examples and practice was distributed as a challenge in the same format as practice problems and students were asked to complete it. E-learning that makes it possible to study with lecture slides and to browse answers to practice problems was provided for lesson preparation and revision in and outside of classes. At the beginning and the end of the course, students were questioned about their level of term recognition and awareness in the classes. This study analyses this information and reports on changes in level of term recognition and awareness.**

Keywords- Operations Research, Recognition level of technical terms, Survey about attitude, Blended learning, Exercise, Assignment

I. INTRODUCTION

In Operations Research (OR) classes as one type of information science lectures, we believed that the contents of classes would not be well understood with only explanations of and solutions to problems. Therefore, we incorporated practice into these classes. The contents of the textbook were explained. During practice, worksheets that made it possible to practice by filling in the blanks were distributed. As a result, almost all students did the practice sheets and handed them in. For the practice portions of all chapters, the calculation method was explained so that it was possible for students to obtain solutions if they filled in the appropriate figures in each box of the calculation formula. It was made clear to students that if they had a calculator, they would be able to solve OR problems themselves. This method was adopted with the expectation of understanding the nature of OR and fostering people who can solve problems that they come up against in society through the experience of solving problems. The contents of these lectures have been made into an Operations Research textbook [1].

Following the textbook, slides are shown, there are lectures on problems and their formularization, and solutions are explained using examples in these classes. After these classes, a sheet with blank boxes for answers to similar problems in the same format as the examples was distributed and students were asked to complete it as practice. After giving the answers to the practice problems at the next week, a sheet with problems similar to examples and practice was distributed in the same format as practice and students were asked to complete it. In this way, OR classes were conducted focusing on practice [2].

How to learn is different for each student. A perfect media for all students does not exist. It is possible to support many and various student learning styles and to deepen understanding by using more than one media [3][4]. The use of e-learning, which cooperates with and expands the class, in the classroom is a useful means to improve the traditional class [5][6]. Reading class content on the web increases opportunities to review and prepare. It is tied with settlement of the contents to learn many times until a learner is convinced. Even if a learner is absent from a class, the class content can be reviewed at his/her convenience.

Approximately 80% of classes using e-learning in Japanese higher education are blended learning [7]. In Japan, the number of blended classes coordinating lectures and e-learning is particularly high. These are producing effects on studying through reciprocal complementation of lectures and e-learning [8]. There are expectations for this type of blended classes [9]. The authors have been implementing blended learning for the past ten years or so and have produced good results [10]. The authors are implementing blended classes for an introduction to computers. We can report that there were positive results from the development of classes with integrated media such as organized lecture notes, e-learning and short tests. In addition, we reported that it was possible to even further boost effects due to an increase in interaction with teachers through a questionnaire about the level of understanding [11]. The results of a comparison of the use of e-learning in and outside of classes showed that almost the same effects could be obtained with both methods [12][13].

The structure of the classes can be roughly divided into lecture, practice and experiment. Blended classes for which we have made reports up until now have been lecture-type classes. Accordingly, in Operations Research classes that are practice-type, in order to produce results by implementing blended classes, preparing e-learning that makes it possible to study with the lecture slides and to browse answers to practice problems made it possible to use e-learning in lesson preparation and revision in and outside of classes.

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This paper sets out to discover the effects of blended practice-type classes, by analyzing the answer to questionnaire survey about their level of recognition of terms used in the classes and awareness at the beginning and end of the course. This paper explains class contents and methods, analyses the information obtained from questionnaires, and reports on changes in level of recognition of terms and awareness.

II. CLASS DESIGN AND CONTENTS

Class contents are shown in TABLE I. The textbook [1] is composed of 14 chapters with representative OR techniques and in classes, the 7 problems shown in TABLE I from these 14 chapters were taken up. The target was an elective course for the latter period of the 3rd year of university information studies. There were 20 students in the 2012 class. There were a total of 15 classes of 90 minutes each.

The textbook is composed of goals, definitions of problems, solutions to problems, practice and challenges for each technique. It was assumed that they would be used in lectures, but at the beginning of each chapter, the goal was explained so that they could also be used in practice and experiments. Next, the problems in the chapter were explained and defined so that the students understood the content. Actual examples were used and there were no omissions, giving a detailed explanation of techniques and methods or the solution to the problem. After this, practice problem sheets were distributed and practice in actually calculating and solving problems similar to the examples was conducted. These problems can be solved with either a calculator or a pen and paper. At this time, the practice problems sheet is prepared with the required tables and text and is in a framework in which the problem can be solved by filling in figures and results in the blanks. Furthermore, two challenges are also in the textbook to offer an opportunity for practice for those who wish to further cultivate their understanding. This is a feature that does not exist in similar books.

If the problems could not be completed within the time limit, students were instructed to finish and hand it in by the next week. The answers to practice questions were explained the following week. One of the ways of using these challenges is to distribute challenge sheets with the same format as for practice and have the students solve them. Students were made to hand these practice and challenge sheets in as many times as it took until they got the correct answers. Furthermore, final exams were implemented. In any case, understanding of each technique is improved by repeatedly solving three types of problems: the example problem that shows the solution method, the practice problem and the challenge.

From the actual experience [2] of giving lectures, the explanation of goals, problem definition and problem solution took between 15 and 40 minutes so it was possible to use between 35 and 60 minutes for practice, ensuring plenty of time. Lectures, practice and challenges for one chapter were completed every two weeks.

At the beginning of the class, the answers to the previous week's practice are given. Then, after explaining the goal of that day's problem technique, the formulization and method for solving the problem are explained. Lecture contents are explained through slides projected on the screen. After that, a practice sheet with blanks is distributed in order to implement practice for the chapter that has been explained. Then the students are asked to solve the problems. When the problems are solved, the students hand them in.

A. Class Goals and Aims

OR is a mathematical model for decision-making. Many mathematical models are proposed. The goal of this class is to explain these techniques, to actually practice these techniques after the lecture, to cultivate understanding and to be useful in problem solving in society. In addition, through various activities in these lectures, the ability to think and solve problems is cultivated.

TABLE I. PLANS AND DESIGN ON OPERATIONS RESEARCH.

Week	Lecture Contents	During the Class							Outside the Class			
		Lecture Slides	Practice Slides	Practice Sheets	Challenge Sheets	Instruction for Class Plan and Method	Awareness Survey	Recognition Survey	Lecture Slides	Practice Slide Study	Evaluation Sheets	Report Framework
1	Chapter 4 Transportation	Chapter 4		Practice 1		Distribution of Materials	Survey prior to course	Survey prior to course	Chapter 4		Submit prior to course	
2	Challenge 1		Practice Answer 1		Challenge 1					Practice Answer 1		
3	Chapter 5 Assignment	Chapter 5		Practice 2					Chapter 5			
4	Challenge 2		Practice Answer 2		Challenge 2					Practice Answer 2		
5	Chapter 6 Travelling Salesman	Chapter 6		Practice 3					Chapter 6			
6	Challenge 3		Practice Answer 3		Challenge 3					Practice Answer 3		
7	Chapter 7 Sequencing	Chapter 7		Practice 4					Chapter 7			
8	Challenge 4		Practice Answer 4		Challenge 4					Practice Answer 4		No.1 (Chapters 4,5,6,7)
9	Chapter 8 Shortest Path	Chapter 8		Practice 5					Chapter 8			
10	Challenge 5		Practice Answer 5		Challenge 5					Practice Answer 5		
11	Chapter 9 Schedule Planning	Chapter 9		Practice 6					Chapter 9			
12	Challenge 6		Practice Answer 6		Challenge 6					Practice Answer 6		
13	Chapter 10 Replacement	Chapter 10		Practice 7					Chapter 10			
14	Challenge 7		Practice Answer 7		Challenge 7					Practice Answer 7		No.2 (Chapters 8,9,10)
15	Overall Practice						Survey after course	Survey after course			Submit after course	

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The aims of this class are to understand the selected mathematical models in OR and the algorithms of these techniques so that students can solve the problems according to these algorithms.

B. Class Design

Explanations were given based on the class planning and design in TABLE I. In the first week, class plan explanations were distributed and class planning was explained. After that, an initial survey of term recognition and awareness was conducted. Based on the textbook, the goals, problem definition and solution method for the example were explained for Chapter 4 Transportation. Next, practice sheets were distributed and students were asked to solve the practice problems referring to the explanation of the solution method for the example. At that time, students were given advice to browse the e-learning lecture slides and refer to them. During practice, the teacher went around the classroom and accepted a question. Students were observed helping each other. Those who came up with the answers were asked to submit their practice sheets. Those who didn't come up with the answers were asked to bring their completed practice sheets to the professor's office before the next class.

The next week, the answers to the practice problems were given. After that, sheets were handed back to those who had made mistakes in the answers or the calculations. Next, challenge sheets were distributed and students were asked to solve the problems. At that time, the students were advised to browse the e-learning lecture slides and refer to them. Those who came up with the answers were asked to submit their challenge sheets. Those who didn't come up with the answers were asked to bring their completed challenge sheets to the professor's office before the next class.

In the 3rd week, the goals, problem definition and solution method for the example were explained for Chapter 5 Allocation. Next, the students were asked to solve practice problems in the same way as for Chapter 4 and submit them. In the 4th week, the students were asked to solve challenge problems in the same way as for Chapter 5 and submit them. In this way, the class got through one chapter every 2 weeks.

The submission of practice and challenge problems was repeated until the answer was correct. If a problem sheet was to be given back, mistakes on the sheet were marked with a colored pencil. There were some students who took a long time to get the right answers even though they were able to browse e-learning documents after the answers were explained in class. In the end, 7 practice and challenge problems were completed in 15 weeks. Post surveys of term recognition and awareness were taken in the 15th week.

Students were asked to fill in the goals, problem definition and discussion for each chapter after downloading framework files and were asked to submit these two reports in the 8th and the 14th weeks.

C. Contents of E-learning

To intensify the effect of this lecture and to enable the students to make a peer assessment, e-learning functions were added as follows: (1) learning with 254 lecture slides; (2) learning with downloadable documents and templates of seven kinds; (3) submitting and uploading exercises of seven kinds; (4) uploading opinions to a bulletin board and browsing them; and (5) sending question mail.

III. Analysis Results and Discussion

For this paper, in order to understand the level of understanding of terms that came up in class contents, term recognition surveys were conducted before and after the course. By conducting study activities related to the classes, an awareness study related to ability was implemented before and after the course in order to understand the changes in awareness related to ability. In order to understand which activities are useful in improving this awareness, students were asked to fill in activities that help to improve awareness in the right-hand column beside the awareness evaluation number in the post-project awareness survey.

Below, we state that significant differences were observed in the significance testing with a significance level of 5%. The symbols m, SD, F, t and p refer to mean, standard deviation, F value, t value for test statistics and probability respectively. The results of the tests show that symbols ***, ** and * are significant with significance levels of 0.1, 1 and 5% respectively. The + symbol shows the significance trend with a significance level of 10%.

A. Changes in Term Recognition

In order to find out whether students have understood the OR related terms that came up in class lectures, the term recognition level survey method [14] developed by Nakamura et al. was used. The 33 terms listed in TABLE II were surveyed twice for recognition (R) before (April) and after (July) the course (N=19). 19 people gave valid responses to this survey. Evaluations were made on three levels of recognition: 3. I understand it, 2. I don't fully understand it but I have heard of it, and 1. I don't understand it. H-check terms for which there is a high likelihood of respondents understanding them were: PC, queue and network and an L-check term for which there is a low likelihood of respondents understanding it was: simulation. These 4 terms were expected and set to be terms that did not change throughout the class.

Results of paired significance tests for recognition of the above-mentioned terms are shown in TABLE II. The results of pre- and post- paired significance tests for the development of average recognition of the 33 terms showed a significant difference with a significance level of 0.1%. It was observed that post-course recognition was higher.

The results of a paired significance tests for average growth of recognition of each term before and after the course showed a significance level of 0.1% for 22 terms, a significance level of 1% for 6 terms and a significance level of 5% for 1 term. This means that recognition levels for these 29 terms had risen after the course. However, through the significance test, 4 terms were observed not to have significant differences. These were all the check terms. PC,

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queue and network were H-check terms. These had high recognition of R=3.0, R=2.6 and R=2.5 before the course and of R=3.0, R=2.8 and R=2.7 after the course respectively with almost no change. It is for this reason that these terms, having had high recognition from the beginning, did not change much due to the classes. In addition, the L-check term 'simulation' was not explained in the classes and the pre-course survey showed low recognition of R=2.1 whereas the post-course survey showed a value of R=2.4 with almost no change. In this way, the 4 check terms that were set to show the validity of the survey were stable and there was no significant difference in the significance test. This can be considered to show the validity of the survey. Due to this fact, it can be said that understanding of the 29 terms that appeared in relation to class contents was improved.

B. Changes in Evaluation Values of Awareness related to Ability

The 35 categories listed in TABLE III were surveyed twice for awareness before (April) and after (July) the course. There were 9 evaluation values: 1. Not at all, 3. Slight, 5. A little, 7. Fairly and 9. Extremely. 19 people responded to this before and after the course.

TABLE II. SIGNIFICANCE TEST FOR TERM RECOGNITION.

Contents	No.	Term	Before		After		Significance Test	
			m	SD	m	SD	t−value	p
Transportation	2	Transportation	1.2	0.4	2.9	0.2	16.7	***
	3	Objective Function	1.4	0.5	2.8	0.4	9.2	***
	4	Restrictions	1.6	0.6	2.8	0.4	9.9	***
	5	Optimal Solution	1.6	0.7	2.7	0.4	5.5	***
	6	Typical Constant	1.3	0.4	2.5	0.7	6.7	***
	7	Optimal Decision	1.3	0.4	2.5	0.6	7.5	***
Allocation	8	Allocation	1.3	0.4	2.8	0.4	10.9	***
Travelling Salespeople	9	Travelling Salespeople	1.2	0.4	2.7	0.4	13.6	***
	10	Setup Fees	1.2	0.4	2.5	0.5	8.5	***
Ordering	13	Ordering	1.4	0.6	2.7	0.4	8.7	***
	14	Johnson Method	1.2	0.4	2.2	0.6	6.5	***
Shortest Route	15	Shortest Route	1.6	0.6	2.7	0.5	8.4	***
	12	Distance Matrix	1.3	0.4	2.6	0.5	9.8	***
	16	Node	1.8	0.6	2.6	0.6	3.5	**
	17	Arc	1.5	0.6	2.4	0.6	4.5	***
	18	Diagraph	1.3	0.5	2.4	0.7	7.4	***
	19	Shortest Route	1.7	0.7	2.6	0.7	4.5	***
Schedule Control Planning	21	Schedule Control Planning	1.6	0.7	2.5	0.6	5.3	***
	22	PERT	1.3	0.4	2.3	0.7	6.5	***
	23	Arrow Diagram	1.6	0.7	2.5	0.6	3.9	**
	24	Critical Path	2.2	0.7	2.8	0.4	3.0	**
Exchange	25	Exchange	1.2	0.4	2.7	0.4	13.0	***
	26	Discounted Value	1.4	0.5	2.3	0.6	5.3	***
	27	Malfunction Probability	1.7	0.7	2.5	0.5	3.7	**
	28	Average Lifespan	1.9	0.8	2.5	0.6	2.2	*
Inventory Control	29	Inventory Control	1.5	0.5	2.3	0.7	6.4	***
	30	Order Point Method	1.4	0.5	2.3	0.5	6.9	***
	32	Storage Costs	1.5	0.6	2.2	0.7	3.6	**
	33	No. of Orders	1.6	0.6	2.3	0.5	3.6	**
Check Terms	31	Simulation	2.1	0.6	2.4	0.7	1.6	
	20	Network	2.5	0.5	2.7	0.4	1.2	
	11	Queue	2.5	0.5	2.6	0.5	0.3	
	1	PC	2.9	0.2	2.9	0.2	0.0	
		Average	1.5	0.3	2.4	0.3	8.9	***

*** p<.001, ** p<.01, * p<.05

Average pre- and post-course evaluation values for all 35 categories were 4.2 and 5.1 respectively. Results of paired t-tests for pre- and post-evaluation values are shown at the bottom of TABLE III. Significant differences in pre- and post-course values were observed in all 35 categories. It was discovered that awareness related to ability had improved as a whole after the course.

The results of t-tests for pre- and post-evaluation values for each category of awareness related to ability are shown in TABLE III. The 20 categories of (2), (6), (7), (14)-(17), (20), (22)-(28) and (31)-(35) were observed to have significant differences. There were no significant difference trends for the 4 categories of (4), (8), (21) and (29). Therefore, it was discovered that awareness evaluation values were improved for these.

One of the goals of the lectures was to cultivate the ability to think and to solve problems through various activities. It can be said that evaluation values for evaluation categories (26) Ability to solve problems and (28) Ability to think which are related to this were improved.

It was discovered that all evaluation values for categories (31) to (35) related to knowledge of Operations Research improved. It is thought that by solving 3 problems in each chapter: example, practice and challenge, knowledge about OR and decision-making methods, expressing social phenomena in mathematical models, knowledge about algorithms to solve the mathematical models, and volition to solve social phenomena are increased.

IV. CONCLUSION

After a detailed explanation of the example solution, practice problem sheets with a framework for filling in the blanks with numerical values and results are distributed and practice is conducted. Challenges are conducted after explanation of the solution the following week. The effects of the class method focusing on practice were reported. The most frequent activities that helped with development were: listening to the lecture and the explanation of answers, preparation for and revision of lessons, and asking questions, etc. The following was discovered through an analysis of educational information that was gained from this class.

(1) Term recognition improved overall after the course. All 29 terms, not including the check terms, had improved after the course.

(2) Awareness related to ability improved overall after the course. The 20 awareness categories out of the total 35 categories improved after the course. In particular, the 5 categories for awareness related to OR class contents all improved.

Students submitted practice problem and challenge problem sheets several times until they got the answers right. We would like to study the effects of this in the future. In addition, we would like to be more inventive with the practice methods and research the role of media in further improving effects.

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TABLE III. SIGNIFICANCE TEST OF AEARENESS RELATED TO ABILITY.

Awareness related to Ability	Before		After		Significance Test	
	m	SD	m	SD	t-value	p
(1) Interest in and curiosity about computers	6.7	1.5	6.9	1.4	0.7	
(2) Understanding of computers	4.7	1.6	5.5	1.3	2.7	*
(3) Computer operation skills	4.7	1.5	5.2	1.3	1.4	
(4) Computer usage methods and broadening of situations	4.7	1.6	5.5	1.6	2.1	+
(5) Ability to set challenges, ability to discover problems	4.3	1.7	4.6	1.4	1.1	
(6) Ability to plan, to do things in a planned manner	4.1	1.5	4.8	1.1	2.8	*
(7) Cultivation of understanding of knowledge learned	4.5	1.0	5.2	1.1	2.9	**
(8) Ability to study by oneself, ability to learn	4.3	1.2	5.0	1.4	2.0	+
(9) Ability to gather information, ability to conduct research	4.9	1.4	5.5	1.8	1.2	
(10) Ability to sort through related information or data	4.4	1.7	4.9	1.4	1.2	
(11) Ability to analyse information	4.5	1.3	5.1	1.8	1.3	
(12) Ability to express thoughts in writing	3.9	1.7	4.4	1.8	1.7	
(13) Ability to express thoughts through media other than writing	3.9	1.9	4.1	1.6	0.5	
(14) Ability to speak and explain things to others in an easy-to-understand manner	3.7	1.9	4.7	1.9	4.1	***
(15) Ability to make presentations	3.9	2.0	4.6	2.0	2.6	*
(16) Ability to listen to what people are saying and ability to ask people questions	4.7	2.1	5.4	1.8	2.3	*
(17) Communication ability	4.5	2.3	5.5	2.1	2.7	*
(18) Ability to appropriately self-evaluate one's thoughts	4.3	1.6	4.7	1.6	2.0	+
(19) Ability to appropriately evaluate other people's thoughts	4.8	1.8	5.3	1.5	1.9	+
(20) Ability to correct and improve on one's own thoughts	4.5	1.6	5.1	1.3	2.6	*
(21) Ability to pursue matters deeply, ability to explore matters	4.3	1.7	4.9	1.3	2.1	+
(22) Ability to execute, ability to practice, ability to put into action	4.1	1.4	5.1	1.6	3.3	**
(23) Ability to cooperate with others, ability to study in cooperation with others	4.5	1.7	5.6	1.9	3.1	**
(24) Sense of accomplishment, sense of satisfaction	4.6	1.7	5.6	2.1	2.5	*
(25) Sense of fulfilment, sense of achievement	4.8	1.7	5.6	2.1	2.3	*
(26) Ability to solve problems	4.4	1.5	5.1	1.4	2.2	*
(27) Ability to construct and create knowledge	4.0	1.7	4.9	1.4	3.1	**
(28) Ability to think, consider and come up with ideas by oneself	4.2	1.5	5.2	1.8	2.4	*
(29) Creativity/ability to create	4.3	1.6	4.9	1.7	1.8	+
(30) Interest in and curiosity about this field	4.8	1.8	5.2	1.6	1.0	
(31) Knowledge about Operations Research	2.1	1.6	5.1	1.4	6.1	***
(32) Knowledge about decision-making methods	2.5	1.6	4.7	1.4	5.1	***
(33) Knowledge about expressing current societal problems in mathematical models	2.2	1.4	4.4	1.2	6.5	***
(34) Knowledge about algorithms that solve mathematical models	2.4	1.6	4.6	1.3	6.2	***
(35) Volition to solve current societal problems	3.4	1.5	4.8	1.5	3.8	**
Average	4.2	1.2	5.1	1.2	4.8	***

*** p<.001, ** p<.01, * p<.05

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Practice and Effects of Programming Education in Blended Quiz Production

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***Abstract*—Blended classes are conducted for the purpose of improving the practices and effects of programming education. Using an environment in which students make quizzes collaboratively or independently, as well as an e-learning system and mutual assessment activity among students, students compose quizzes and evaluate one another in classes. This paper describes differences of consciousness in different performance groups based on the results of a questionnaire administered to students, preferred items for making quizzes, and a comparison of test scores obtained during the first year and second year of Technical College.**

Keywords–programming education; collaborative learning; quiz-making; Moodle

I. INTRODUCTION

Aiming at improving the effects of programming education, each unit was conducted based on blended learning combined with teacher-centered class, individual learning using e-learning and collaborative learning by students' mutual assessment [3]. The results of a questionnaire after finishing all the units and tests revealed that quiz-tests were effective in developing students' knowledge of programming. However, it was found that there were cases when students happened to get correct answers of quiz-tests by guessing.

Therefore, the purpose of this study is to develop an accurate knowledge of students and verify the effect of blended learning after practicing activities of students' making quizzes, which was presumed to be more effective in developing students' understanding of programming than their solving given questions.

Section II explains the collaborative quiz-making environment based on Moodle (Modular object-oriented dynamic learning environment). Section III describes a practical example conducted for unit learning and feedback after practicing each unit. The conclusion of this study and future considerations are expressed in Section IV.

II. COLLABORATIVE QUIZ-MAKING ENVIRONMENT BASED ON MOODLE

The collaborative quiz-making environment module was developed to make multiple-choice questions that can be leveraged with the quiz module as a standard module of the Moodle [3]. The development environment is Moodle 1.9 on Linux server with PHP (Hypertext Preprocessor) 5 script language, MySQL 5 database management system, and Apache 2 hypertext transfer protocol sever [4]. Figure 1 is a use case diagram by UML(Unified Modeling Language) of collaborative quiz-making environment. The collaborative quiz-making environment has the following three functions:

(1) *Students' quiz-making* function

Students can make multiple-choice questions without being aware of the tags needed to make quizzes with Moodle.

(2) *Mutual evaluation among students* function

Through the evaluation items produced by teachers, students can evaluate quizzes made by other students.

(3) *Teachers' quiz-registering* function

Teachers can use the quizzes made by students in quiz modules by registering quizzes made by students into Moodle's standard quiz bank.

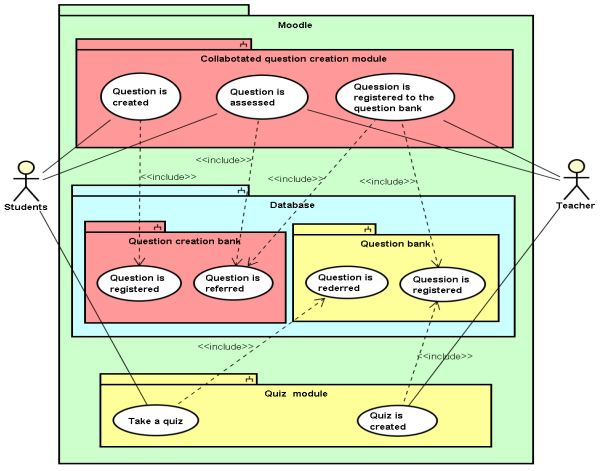

Figure 1. A use case diagram of collaborative quiz-making environment.

III. PRACTICE AND EVALUATION OF CLASSES

Programming education was conducted with a collaborative quiz-making environment for 39 students of the second year of the Electronic Information Department of Technical College. Immediately after one unit of the programming education classes was completed, quiz-making and evaluation activities were conducted. Students were asked to do the activities 3 times in substitution, operation, and input–output, in selection, and in recursion. The quiz to be made included multiple-choice questions for programs of C language grammar. Each student composed a single question and conducted a mutual evaluation for the questions

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with peer students having the same last digit of their student number.

The outline of programming education in blended making quizzes is presented in Figure 2. For each unit, blended classes which consist of individual learning with e-learning quizzes and collaborative learning with the collaborative quiz-making environment were conducted.

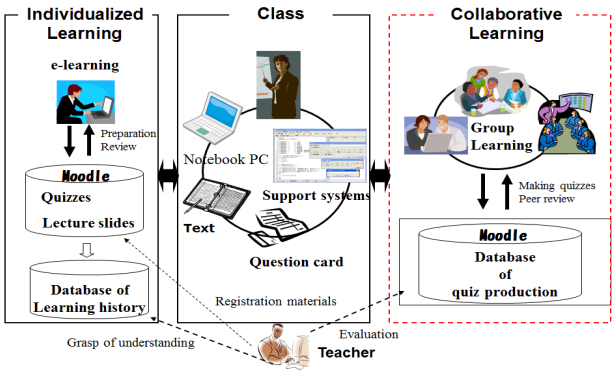

Figure 2. Component of blended classes.

A. *Differences in students' consciousness by performance score group*

After the 30th class, a questionnaire with 45 items related to quiz-making, evaluation, and the collaborative quiz-making environment shown in Table I was administered to 39 students. The questionnaire was administered with the five-level rating evaluation from "5: I think so." to "1: I do not think so". According to the score x of four manuscript tests conducted in 2012, the students were divided into an ascendant group ($x \geq m+SD/2$, 17 students), a median group ($m-SD/2 \leq x < m+SD/2$, 12 students), and a descendant group ($x < m-SD/2$, 10 students), where m and SD respectively denote the average score and standard deviation. For the students answering "3: yes and no" in each group, a significance test was conducted to ascertain whether the average score deviated to the positive side or negative side or did not deviated at all. The result is presented in Table I. The signs of m, SD, t, p, and F in Table I represent the mean, standard deviation, t value, significant probability, and the F value, respectively.

The significance test, conducted for all 45 items, found that each group deviated to the positive side with a significance level of 1%. Additionally, the significance test on each item revealed that the quantities of items which significantly deviated to the positive side in the ascendant group, the median group, and the descendant group were 26, 21, and 29, respectively.

Next, analysis of variance was conducted for each item. The result shown in Table I demonstrates that only the 24th item (The quizzes made by others are difficult.) was significant. As a result of performing multiple comparisons using the LSD (Least Significant Difference) method on the 24th item, a significant difference was found between the ascendant group and the descendant group, suggesting that the students in the descendant group felt that problems made by others were more difficult than those in the ascendant group. The LSD is a method for multiple comparisons after the analysis of variance.

The items that deviated significantly to the positive side suggested the following:

(1) Items that deviated significantly to the positive side irrespective of the score group

The first item and the 20th item showed that students thought it was difficult for them to make quizzes and give advice related to choices (wrong answers). The largest t value in the descendant group was the first item, "making quizzes is difficult," which deviated significantly to the positive side.

The second and fourth items and the 25th and 27th items suggested that students thought that they were able to improve the level of understanding of what they had learned and were able to gain complete control over their knowledge by making quizzes and solving the quizzes made by others.

Moreover, the 40th and 41st items revealed that students were able to accept criticism and advice from others gratefully, which helped them modify their quizzes.

(2) Items that significantly deviated to the positive side were only those of the ascendant group

Only the fifth item deviated significantly to the positive side in the ascendant group, which showed that the students in the ascendant group thought it was more effective to make quizzes than to solve them. For the students in the ascendant group, quiz-making activities might improve the level of understanding of what they have learned.

(3) Items that significantly deviated to the positive side only in the descendant group

The 18th and 19th items showed that the students in the descendant group thought that they were able to improve their motivation for learning and obtain knowledge completely by thinking about alternative choices (wrong answers) for multiple-choice questions. Furthermore, the 23rd item showed that they thought that they could obtain knowledge completely by thinking about advice for wrong answers. Additionally, the 33rd item found that they thought that their use of evaluation activities had improved the level of understanding of what they had learned.

Consequently, although students felt it was difficult to make quizzes, they thought that the activities of thinking about wrong answers and advice and those of evaluation can engender improvement of the level of understanding of what they had learned.

B. *Opinions about making quizzes*

The students were asked to write freely the reasons why they felt it was difficult to make quizzes. The main reasons are shown below:

(1) Benefits of making quizzes

・Making quizzes helps me review what I have learned.

・Making quizzes can improve my understanding of programming.

(2) Shortcomings of making quizzes

・Making quizzes was difficult, so I could not get motivated by myself.

・It took much time to do it.

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(3) Benefits of evaluation activities

・It serves as a review.

・Thanks to this activity, I was able to understand what is important in programming.

(4) Shortcomings of evaluation activities

・I did not know whether I made correct evaluations.

・When I did not understand them, I was unable to make evaluations.

The results of free description suggested that students thought that quiz-making and evaluation activities were able to help them improve their understanding as a review. However, for the students who felt it was difficult to make quizzes alone, they turned out to be demotivating. In addition, some students turned out to feel concerned about making evaluations.

C. *Preferential items of making quizzes*

Asking students to assign the order of priority (1–6) of items on which they placed importance in making quizzes (Table II), a cross table of the result of each item was conducted.

TABLE II. CROSS TABLE OF QUIZ-MAKING PREFERENTIAL ITEMS AND TESULTS OF χ^2 TESTS

Priority order / Item	Actual frequency							Expected frequency						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
Difficulty level of question	4	9	11	7	7	1	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Option of question (Wrong answer)	1	6	11	12	7	2	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Advisory statement for wrong answe	0	0	0	6	15	18	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Learning contents of question	22	9	3	5	0	0	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Originality of question	3	3	5	4	9	15	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Helpful for learners	9	12	9	5	1	3	39	6.5	6.5	6.5	6.5	6.5	6.5	39
Total	39	39	39	39	39	39	234	39	39	39	39	39	39	234

	Adjusted residual						Significance test					
Difficulty level of question	-1.0	1.0	1.8	0.2	0.2	-2.2			*			
Option of question (Wrong answer)	-2.2	-0.2	1.8	2.2	0.2	-1.8			*	**		
Advisory statement for wrong answe	-2.5	-2.5	-2.5	-0.2	3.3	4.5					**	**
Learning contents of question	6.1	1.0	-1.4	-0.6	-2.5	-2.5	**					
Originality of question	-1.4	-1.4	-0.6	-1.0	1.0	3.3						**
Helpful for learners	1.0	2.2	1.0	-0.6	-2.2	-1.4		**				

**: $p < .01$, *: $p < .05$

A χ^2 test was conducted in the 6 × 6 contingency table. Results show that the frequency deviation was significant ($\chi^2(25) = 160.15$, $p<.01$). Then, among the cells in which significant difference was found by residual analysis, the cells with positive residual error were marked with *.

According to the results of residual analysis shown in Table II, students assigned priority to what they learned, and to what was helpful to other students in making quizzes. They did not regard the originality of advice for wrong answers and quizzes as important.

D. *Comparison of test performance between the presence or absence of quiz-making activity*

A regular examination with the same 13 problems was conducted during the 2011 school year, when students did not experience a quiz-making activity, and during the 2012 school year, when they experienced it. The problems are presented in Table III. The problems consist of the multiple-choice questions to test the knowledge of C language, in addition to questions to test the programming ability to make an algorithm and represent it in a C program. In each school year, students solved e-learning quizzes. Each question's average score was analyzed using a significance test. The results are shown in Table IV.

Significant differences were found among the average scores of all 13 questions, showing that the result of the 2012 school year, with quiz-making activity, was higher. Additionally, the SD in 2012 was smaller, so the variation of scores was smaller.

TABLE IV. COMPARISION OF TWO YEARS' TEST SCORES

Category	Question	Perfect Score	2011		2012		Significance Test	
			m	SD	m	SD	t	p
Questions to test C language knowledge	Q.1	16.0	12.5	4.0	11.4	6.2	0.9	
	Q.2	20.0	15.9	5.6	16.6	5.0	0.6	
	Q.3	16.0	11.3	4.4	12.7	4.1	1.5	
	Q.4	12.0	10.0	3.2	10.4	2.5	0.7	
	Q.5	16.0	12.9	4.5	14.7	3.6	2.1	*
	Q.6	12.0	9.6	3.5	10.7	3.0	1.5	
	Average	15.3	12.0	2.8	12.8	2.8	1.2	
Questions to test programming ability	Q.7	20.0	16.6	5.5	16.5	5.9	0.1	
	Q.8	15.0	8.0	6.4	9.9	6.4	1.4	
	Q.9	14.0	11.1	4.7	12.1	3.8	1.1	
	Q.10	15.0	13.3	4.0	14.1	2.6	1.1	
	Q.11	12.0	7.6	4.6	9.8	3.2	2.6	*
	Q.12	10.0	7.3	4.3	8.9	2.9	1.9	
	Q.13	12.0	10.2	3.7	11.1	1.8	1.5	
	Average	14.0	10.6	3.5	11.8	2.3	1.8	
Average score of the whole questions			11.3	3.2	12.3	2.6	2.1	*

*: $p < .05$

With each question's average score, only question 5 to test knowledge (to solve values of variables and pointer variables when programming is conducted) and question 11 to test programming ability (to create a program for a function which assigns an argument value to a 2D array) showed significant difference. The results of the tests suggest that blending quiz-making activities was effective, although only slightly so, for improving programming learning.

IV. CONCLUSION AND FUTURE PROBLEMS

Aiming at improving programming education, class practice was conducted with a blended quiz-making activity using the collaborative quiz-making environment. According to the questionnaire administered after class practice, students, irrespective of performing score groups, reported that quiz-making activities were helpful for their understanding of what they had learned and for making their knowledge complete. At the same time, they thought it was difficult to make quizzes.

The students in the ascendant group thought that making quizzes was more effective than solving them. In contrast, the students in the descendant group thought that thinking about alternative choices led to improved understanding and secured knowledge and that evaluating quizzes made by others improved their own understanding. In making quizzes, students assigned primary importance to what they had learned. They gave secondary emphasis to what was helpful to them. Comparison of the test results obtained during two years revealed that quiz-making activities were helpful, but only slightly, to improve what students had learned and to reinforce their knowledge.

In future studies, several ways to examine should be striven to make students feel it is less difficult to make quizzes, for example by seeking points at issue in their textbook and by reviewing points before quiz-making activities.

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TABLE I. COMPARISION OF TWO YEARS' TEST SCORES

No.	Eevaluation Items	(1) Ascendant				(2) Median				(3) Descendant				Distribution of score groups	Multiple comparison by LSD method		
		m	SD	t	p	m	SD	t	p	m	SD	t	p	F	(1) vs. (2)	(2) vs. (3)	(3) vs. (1)
1	Making quizzes is difficult.	3.9	0.8	4.7	**	4.3	1.2	4.0	**	4.4	0.5	8.6	**	1.2			
2	Making quizzes improves understanding of learning contents.	4.0	0.6	6.7	**	4.2	0.9	4.3	**	4.0	0.8	3.9	**	0.2			
3	Making quizzes improves learning motivation.	3.1	0.9	0.5		3.0	1.2	0.0		3.4	0.8	1.5		0.5			
4	Making quizzes makes learning contents complete.	3.9	0.6	6.1	**	4.1	0.8	4.7	**	4.0	0.7	4.7	**	0.3			
5	Making quizzes is more effective for solving quizzes.	3.5	0.7	2.7	*	2.8	1.2	0.5		3.4	1.0	1.3		1.7			
6	Making quizzes is helpful to reviewing learning contents.	3.8	0.9	3.8	**	4.0	0.9	4.1	**	3.8	0.8	3.2	*	0.2			
7	Making quizzes improves program-making ability.	3.9	0.8	4.7	**	4.2	0.9	4.3	**	3.7	1.1	2.1	+	0.7			
8	Making quizzes improves knowledge of programming language grammar.	3.6	0.9	2.9	*	4.2	0.9	4.3	**	4.0	0.9	3.4	**	1.2			
9	Making quizzes improves program knowledge.	3.7	0.8	3.4	**	4.2	0.7	5.6	**	3.9	0.7	3.9	**	1.2			
10	You made quizzes expecting that they would be helpful to other learners.	3.6	1.2	2.0	+	3.6	1.2	1.6		3.4	0.7	1.8		0.1			
11	You made quizzes being aware of what was important in learning.	3.7	0.9	3.2	**	3.5	0.9	1.9	+	3.8	0.9	2.8	*	0.3			
12	You made quizzes being aware of intention of giving quizzes.	3.4	1.0	1.5		3.6	0.9	2.2	*	3.6	0.7	2.7	*	0.3			
13	You can not make quizzes from matters that I do not understand.	4.2	1.0	5.3	**	4.7	0.7	8.9	**	4.1	1.4	2.5	*	1.0			
14	You studied in advance to make quizzes.	2.8	1.1	0.8		3.5	1.2	1.4		3.2	0.9	0.7		1.6			
15	You had a talk with other learners to make question.s	3.4	1.2	1.2		3.2	1.0	0.6		3.3	1.1	0.9		0.1			
16	Thinking about choices (wrong answers) is difficult.	3.6	1.0	2.4	*	3.3	1.4	0.8		4.0	0.8	3.9	**	1.0			
17	Thinking about choices (wrong answers) improves understanding of learning contents.	3.5	1.1	2.0	+	3.6	1.1	1.9	+	3.4	0.7	1.8		0.9			
18	Thinking about choices (wrong answers) improves learners' motivation.	2.9	0.9	0.3		2.9	1.3	0.2		3.5	0.5	3.0	*	1.3			
19	Thinking about choices (wrong answers) makes the knowledge of learning content secure.	3.3	1.2	1.0		3.1	1.2	0.2		3.6	0.7	2.7	*	0.6			
20	Thinking of advice for choices (wrong answers) is difficult.	4.1	0.9	4.9	**	4.3	0.9	5.0	**	4.1	0.7	4.7	**	0.2			
21	Thinking of advice for choices (wrong answers) improves understanding of learning content.	3.8	0.9	3.8	**	3.6	1.0	2.0	+	3.5	0.7	2.2	+	0.5			
22	Thinking of advice for choices (wrong answers) improves learners' motivation.	2.9	0.9	0.5		2.7	1.4	0.8		3.1	0.6	0.6		0.5			
23	Thinking of advice for choices (wrong answers) makes the knowledge of learning contents secure.	3.5	1.1	1.7		3.5	1.4	1.3		3.6	0.7	2.7	*	0.0			
24	Quizzes made by others are difficult.	3.1	0.7	0.4		3.7	0.9	2.6	*	3.9	0.6	5.0	**	5.0 *			*
25	Solving quizzes produced by others improves understanding of learning content.	3.9	0.8	4.7	**	4.6	0.5	10.7	**	4.1	0.7	4.7	**	2.9			
26	Solving quizzes made by others improves learners' motivation.	3.4	1.0	1.7		3.8	1.1	2.3	*	3.9	0.9	3.3	**	0.8			
27	Solving quizzes made by others makes the knowledge of learning contents secure.	3.8	0.8	4.2	**	4.2	0.8	4.8	**	4.2	0.8	4.8	**	1.4			
28	Quizzes made by others make you aware of what is important in learning.	3.5	0.9	2.5	*	4.0	0.6	5.7	**	3.8	0.6	4.0	**	1.5			
29	Blanks in quizzes made by others are appropriate.	3.6	0.8	3.0	**	3.9	0.7	4.7	**	3.8	0.6	4.0	**	0.8			
30	Wrong answers made by others are appropriate.	3.6	0.8	3.4	**	3.7	0.9	2.6	*	4.0	0.8	3.9	**	0.7			
31	Advice for wrong answers made by others is appropriate.	3.5	0.7	3.0	**	3.5	0.9	1.9	+	3.6	0.5	3.7	**	0.1			
32	Evaluating quizzes made by others is difficult.	4.2	0.8	6.0	**	3.6	1.0	2.0	+	3.8	0.4	6.0	**	2.0			
33	Evaluating quizzes made by others improves understanding learning contents.	3.2	1.3	0.6		3.3	1.2	1.0		3.9	0.7	3.9	**	1.3			
34	Evaluating quizzes made by others improves learners' motivation.	2.7	1.0	1.2		3.4	1.1	1.3		3.6	1.2	1.6		2.7			
35	Evaluating quizzes made by others is helpful to review learning contents.	3.6	0.8	3.0	**	3.6	1.1	1.9	+	3.8	0.8	3.2	*	0.2			
36	Evaluating quizzes made by others improves program-making ability.	3.0	0.9	0.0		3.2	1.2	0.5		3.4	0.8	1.5		0.5			
37	Evaluating quizzes made by others improves the knowledge program language's grammar.	3.4	0.8	1.9	+	3.5	1.1	1.6		3.6	1.1	1.8		0.2			
38	Evaluating quizzes made by others improves program knowledge.	3.4	0.8	2.1	*	3.8	0.8	3.5	**	3.7	1.1	2.1	+	0.9			
39	Evaluations made by others are appropriate.	3.8	0.7	4.7	**	3.8	0.9	3.0	*	3.6	0.7	2.7	*	0.3			
40	You can accept evaluations made by others gratefully.	3.8	1.0	3.3	**	4.1	0.7	5.6	**	3.9	0.7	3.9	**	0.3			
41	Evaluations made by others help you to modify your questions.	4.0	0.9	4.8	**	4.3	0.6	7.0	**	4.2	0.6	6.0	**	0.5			
42	Evaluations made by others help you to modify your questions.	3.6	0.9	2.8	*	3.4	0.9	1.6		4.0	0.7	4.7	**	1.4			
43	The system's quiz-making function is easy to use.	2.8	1.0	0.9		3.1	1.0	0.3		3.4	1.2	1.1		1.2			
44	The system's evaluation function is easy to use.	3.0	1.0	0.0		3.3	0.9	1.3		3.6	0.8	2.3	+	1.4			
45	The system's evaluation browsing function is easy to use.	3.1	1.2	0.2		3.3	1.1	0.8		3.4	0.7	1.8		0.3			
	Average	3.5	0.5	4.3	**	3.7	0.5	4.8	**	3.7	0.5	4.9	**	0.7			

**: $p < .01$, *: $p < .05$, +: $p < .1$

TABLE III. EXAM QUESTIONS

Questions to test C language knowledge	Q.1	Fill in the blanks of algorithm to obtain product power of odds from one to n.
	Q.2	Input integer number data and fill in the blanks of the program to obtain absolute figure abs of the value.
	Q.3	Input n unknowns of data with the keyboard and store them into array a[]. Then fill in the blanks the program to obtain the maximum value amax of the data.
	Q.4	Fill in the blanks of the algorithm to obtain nth multinominal using Horner's method.
	Q.5	Write the value when the following program is conducted (pointer variable).
	Q.6	Fill in the blanks of the program of function DelBlk (), which stores the sequence of blanks in the array s[] as a single blank into the array t[].
Questions to test programming ability	Q.7	Make a program to obtain greatest common division gcd of two natural numbers a and b using the Euclidean algorithm.
	Q.8	Make a program that presents when it is prime number and when it is not when a positive integer n (n>1) is input.
	Q.9	Make a program of function sum () to obtain the sum of integer n to m. Then, n and m are arguments.
	Q.10	Make a program of the function abs_fun() to obtain absolute values of integer data x of arguments.
	Q.11	Make a program of the function fun() to input integer data z in all factors of the nth row and the mth column in integer type 2D array x[N][M] .
	Q.12	Make a program using the function strleng() to the length of the array of arguments.
	Q.13	Make a program using the function swap to interchange the values of integer a and b.

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Video-Based Learning: A Critical Analysis of The Research Published in 2003-2013 and Future Visions

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***Abstract*— Video-Based Learning (VBL) has a long history in the educational design research. In the past decade, the interest in VBL has increased as a result of new forms of online education, such as flipped classrooms, and most prominently MOOCs. VBL has unique features that make it an effective Technology-Enhanced Learning (TEL) approach. This study critically analyzed the current research of VBL published in 2003-2013 to build a deep understanding on what are the educational benefits and effectiveness that VBL has on teaching and learning. 67 peer reviewed papers were selected in this review and categorized into four main dimensions, namely, effectiveness, teaching methods, design, and reflection. In the light of the discussion of current research in terms of these categories, we present the future vision and research opportunities of VBL that support self-organized and network learning.**

Keywords-Video-Based Learning; VBL; MOOC; Blended Learning; Video Design.

I. INTRODUCTION

Video-based learning (VBL) has a long tradition as a learning method in educational classes. First experiments started during the Second World War. Soldiers were then trained with a combination of audio and film strips [12]. As a result, the static film strips helped to increase their skills while saving a lot of time as well. By the late 1960s, educational television was used as an extra tool in classrooms. Also teachers were confronted with videos of their own lessons to reflect on their teaching methods and improve their performance [63]. In the 1980s, VHS videotapes meant a quantum leap as it became much easier to use video in classrooms. But, still, learners were rather passive and could only watch the video. This changed with the rise of digital video CDs in the mid-1990s. Teachers could now add multimedia control and assessment tools by using the video on a computer. Thus, learners became much more active than before. By the 2000s, classrooms got connected to the internet and interactive digital video as well as video conferences became possible. Since then, new technologies such as smartphones and tablets in combination with social media such as YouTube have contributed to increasing social interaction and have made it easier as ever to integrate video applications in education [15][39]. In recent years, VBL publications have increased in order to discuss how VBL can facilitate learning and enhance learner's outcome as well as teacher's performance. Thus, there was a need to collect existing research, document the benefits of video in improving learning, and explore the design and teaching methods in VBL environments. In this study, we critically analyze the research on VBL to answer the following research questions:

1. What are the educational benefits that VBL has on teaching and learning?
2. How VBL technologies enhance students' learning outcome?
3. How educators and researchers design VBL environments?
4. How is VBL used to improve teacher's and learner's reflection?

In order to answer these questions, this paper will discuss different angles of VBL. The remainder of this paper is structured as follows: Section II is a review of the related work. Section III describes the research methodology and how we collected the research data. In Section V, we review and discuss the current research based on several dimensions. Finally, Section VI gives a summary of the main findings of this paper and highlights new research opportunities for future work.

II. RELATED WORK

This section summarizes the previous work most closely related to our study.

Tripp and Rich [77] reviewed 63 studies in order to understand the ability of teachers to reflect on their teaching through video recording. The result of this study was that teachers prefer to use video recording for reflection in collaboration with colleagues than reflecting individually. Also, teachers report that the use of a guiding framework (e.g., rubric, checklist, teaching principles) helps to focus on their reflection by focusing their attention on certain tasks.

Borgo et al., [57] conducted a study to provide an overview of the major advances in automated video analysis and investigate some techniques in the field of graphic design and visualization.

Greenberg and Zanetis [1] reported the positive impact of video broadcast and streaming in education. As a result of their study, the authors encourage teachers and educators to use interactive video training materials in classes especially with children.

Although these studies asserted that the video is a powerful tool in Technology-Enhanced Learning (TEL) and that videos enable teachers to reflect on their teaching, they do not take into account the teaching methodologies, design

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approaches, and the impact of teachers' reflections on their students' learning outcomes. As compared to the above studies, our study adds a wide range of peer-reviewed studies that have been conducted between 2003 and 2013 and provides a quantitative as well as qualitative analysis of the VBL literature. Moreover, we apply a cognitive mapping approach to categorize the VBL publication into several dimensions. The study further provides critical discussion according to each dimension and suggests new opportunities for future work.

III. METHODOLOGY

The research methodology was carried out in two main phases including identification of eligible studies followed by a cognitive mapping approach to categorize the VBL literature into several dimensions.

A. *Identification of Eligible Studies*

The significant research method of identifying papers from Internet resources was applied to collect data in this study [2]. This method was carried out in three rounds. Firstly, we conducted a search in 7 major refereed academic databases. These include Education Resources Information Center (ERIC), JSTOR, ALT Open Access Repository, Google Scholar, PsychInfo, ACM publication, IEEEXplorer, and Wiley Online Library.

Secondly, we searched 21 academic journals in the field of educational technology and TEL indexed by Journal Citation Reports (JCR) including Australasian Journal of Educational Technology, British Journal of Educational Technology, Canadian journal of learning and technology, CITE Journal, The Electronic Journal of e-Learning (EJEL), European Journal of Open, Distance and E-Learning (EURODL), Interactions Journal, The International Journal of Instructional Technology and Distance Learning, International Review of Research in Open and Distance Learning (IRRODL), Journal of Asynchronous Learning Networks, Journal of computer assisted learning (JCAL), Journal of Computing in Higher Education, Journal of distance education, Journal of Interactive Media in Education, Journal of Interactive Online Learning, Journal of Learning Design, Journal of Online Learning and Teaching (JOLT), Journal of Technology, Learning, and Assessment , Learning, Media and Technology, and Turkish Online Journal of Distance Education (TOJDE), using the keywords (and their plurals) "Video-based learning", "VBL", "teaching with interactive video", and "Video Instruction". As a result, 98 peer-reviewed papers were found.

Thirdly, a set of selection criteria were identified as follows:

1. Studies must focus on VBL in educational development. Studies on video coding and semantic retrieval of video were excluded.
2. Experimental or empirical case studies on how learners learn with and from videos were included. Studies of video recording strategies were excluded.
3. Studies that focus on ability of teachers to reflect on their teaching via video recording were included.
4. Studies evaluating the VBL activities and effectiveness in education were included. Studies that focused on video-games and video conferencing tools were excluded.

This resulted in a final set of 67 peer-reviewed studies, which met the selection criteria above. Figure 1 shows the number of VBL publications between 2003 and 2013, which were found to be relevant for this study.

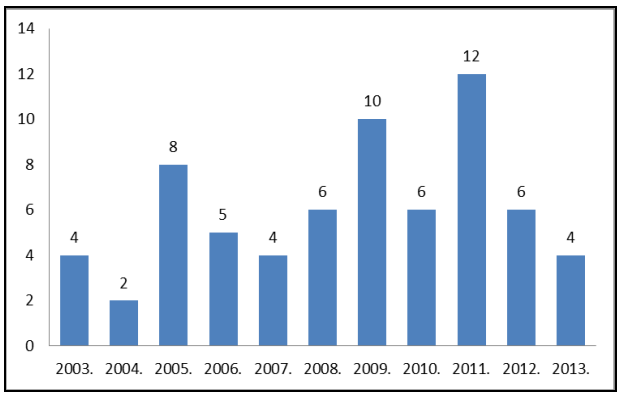

Figure 1. VBL studies by publication year.

B. *Cognitive Mapping Approach*

Cognitive mapping approach is a method enabling the researchers to clarify and categorize the research literature conceptions into several dimensions regarding to the research questions. These dimensions are recorded in graphic flowchart to show the hierarchy of VBL terms [72]. We applied the cognitive mapping approach as a classification technique for dividing the VBL literature into four dimensions relevant to the research questions, namely effectiveness, teaching methods, reflection, and design (see Figure 2).

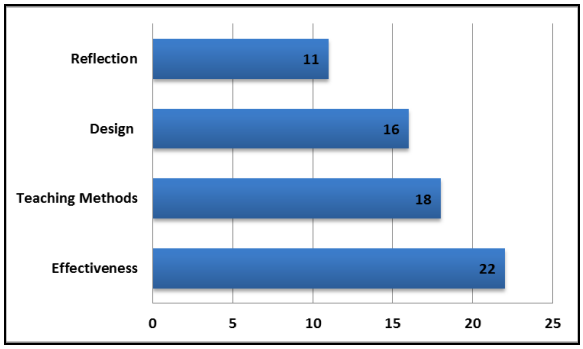

Figure 2. VBL classification map.

In order to capture the information gained from the literature analysis, we created a VBL field diagram (see Figure 3), which has been partitioned into four categories and ten sub-categories.

IV. DISCUSSION

In this section, we critically discuss in details the VBL literature based on the cognitive map dimensions that have been identified in Section III. For the critical discussion part,

we apply the meta-analysis method, which aims to contrast and combine results from several studies into a single scientific work [2].

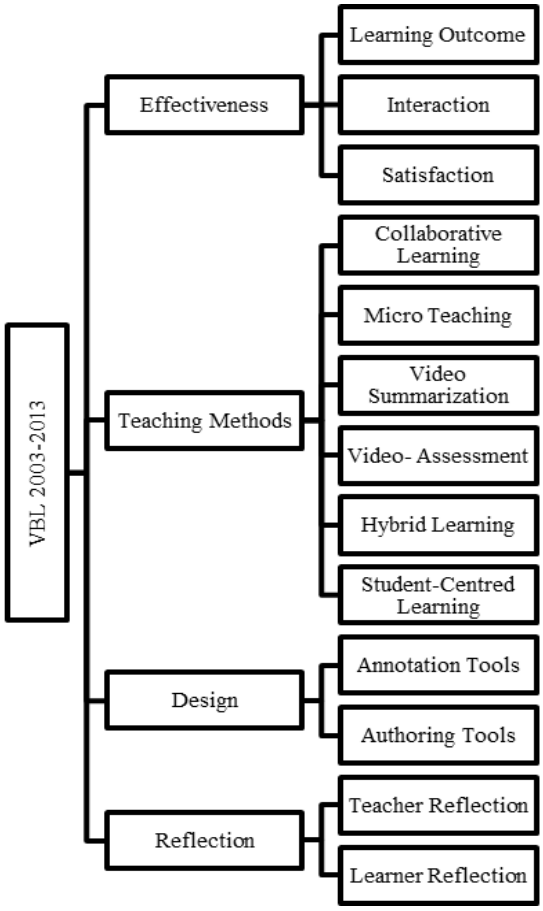

Figure 3. VBL cognitive map.

A. *Effectiveness*

Effectiveness of VBL has received a great deal of attention from academic scientists. 33% of the studies reviewed in this paper examined the effectiveness of VBL. Most of the reviewed case studies asserted the effectiveness of VBL as a powerful medium used in education. We analyzed each study for the following characteristics: research goal, subject, target group, sample size, and summary of results. In the following sections, we discuss the effectiveness of VBL in terms of learning outcome, interaction, and learners' satisfaction.

1) Learning Outcome: A learning outcome (or achievement) can be described as knowledge, skills, and abilities that learners have to achieve as a result of the learning process [47]. Many scholars believe that VBL has the potential to promote the learning outcome. VBL can, for instance, present knowledge in an attractive and consistent manner [19][51]. Further, Kay and Edward [60] and Balslev et al. [74] compared VBL supported by a cognitive approach with text-based learning. The results showed statistically significant differences in improving learners' skills. Moreover, the authors reported that learners liked the followed cognitive approach in which knowledge was generated through step by step learning in video lectures.

In addition, Lin and Tseng [8] and Hsu et al. [13] conducted two studies to investigate the effect of different VBL designs to improve English language skills of K-12 students. The findings indicated that the groups which used VBL outperformed the other groups. Other studies reported the invaluable impact of using VBL in improving teachers' performance. The results asserted that using videos as educational tools improved teaching methods and increased the learning outcome [4][50][63][71].

On the other hand, some studies indicated that there were no statistically significant differences between teaching with video and other methods, and that both are equivalent [23][42][61]. Moreover, Chuang and Rosenbusch [28] pointed out that using only video technology without pedagogy approach doesn't make sense. The authors stressed that video technology should go side by side with pedagogy and provided a constructivist framework to engage learners to learn with videos.

In sum, the reviewed studies indicated that there were conflicting results of using VBL in educational environments as some found it valuable while others reported no significant results. There was, however, an agreement among researchers that VBL in conjunction with appropriate pedagogical methods has the potential to improve the learning outcome.

2) Interaction: Improved interaction and communication among participants is another effectiveness aspect in VBL. DeLoache and Korac [40] reviewed some case studies of using videos with infants. The authors pointed out that video stories indeed improved communication between children. Hakkarainen and Vapalahti [52] investigated learning with video in the forum-theatre. This study showed that VBL can enhance interaction among learners and improve the ability to solve every day social problems.

On the contrary, Muhirwa [37] investigated VBL in TEL environments in Africa pointed out that VBL has a less important role in increasing the interaction among learners due to internet disconnectivity, limited student access to computers, and lack of trained instructors in Africa.

3) Satisfaction: The level of learning satisfaction is important in evaluating the effectiveness of VBL environments. Zhang et al. [19] examined the level of satisfaction through interactive VBL in a study involving 138 students. As a result, students who used a TEL environment that provides interactive instructional video reported higher levels of satisfaction than those in the control group without video.

Moreover, it has been shown that interactive videos have an impact on the emotional side of the learners' behaviour (e.g., real-life interaction, incorporate the different sound and musical effects that can fit the emotional contents of the learning subject) and that videos can improve the attention

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to the subject of the lecture in addition to the positive impact on the learners' motivation level [3][54][68].

B. Teaching Methods

Educationists and scholars use a broad range of teaching methodologies in VBL environments. In this literature review, collaborative learning is a key aspect underlying most of the studies. Other methods involved micro teaching, video summarization, video assessment, hybrid learning, and student-centered learning.

1) Collaborative Learning: In video-based collaborative learning, which focuses on developing, discussing, exploring alternatives rather than directions, learners are able to share responsibilities for their learning [16][19][36]. Most of the reviewed studies validate the efficacy of collaborative VBL, where learners can develop their problem-solving abilities via collaboration with others [1]. These studies reported various educational benefits for learners working cooperatively in teams such as shared goals, ideas, resources, activities, and supporting each other [17][18][29][38]. For instance, Pea and Lindgren [62] investigated which collaboration design patterns are used by learners when they have access to a Web-based video collaboration platform. Five collaboration patterns were identified, namely collective interpretation, distributed design, performance feedback, distributed data coding, and video-based prompting. These patterns support teacher-centred learning by providing knowledge and allowing learners to discuss and find solutions.

2) Micro Teaching: The micro teaching method was used in some studies as a teaching practice with a smaller class size and time (e.g., four to nine learners in a class that is held for five to ten minutes). Educators are able to give learners some quick and easy feedback on their learning performance through video podcasts [21]. Finlay et al. [34] reported that learners' responses on micro teaching with video podcasts are very positive. The authors, however, noted that the video of 10 minutes length was too long for many learners and found that the shorter video podcasts (4-5 minutes) have the advantage of giving greater flexibility in micro teaching lessons. Other studies showed that micro teaching provides a friendly and supportive learning environment [43][76].

3) Video Summarization: Video summarization technique extracts important information and provides short but informative summary of the lecture content [11][78]. Chang et al. [79] designed a keyword-based video summarization learning platform (KVSUM) which provides a keyword cloud as a textual surrogate to support learners to organize information of videos and enhance them to follow the videos and reducing the learning time.

4) Video Assessment: A video assessment is short video that simulates real life activities and provides possible responses to the several daily problems. Learners are asked to select which of the responses they would take in these circumstances. Afterwards, teachers discuss each response and evaluate learner's responses [22][56].

5) Hybrid Learning: Hybrid Learning has become one important TEL model, by integrating online learning and traditional face-to-face classroom together [25][59]. Pang [81] conducted a study by following a hybrid learning approach that uses video-based learning materials in a Physical Education course. In this course, the trainer can review the learner's actions video, pick out the wrong actions, and provide feedback. Then, students can reflect, find out mistakes. The experiment shows that 80.9% out of learners think that the video review indeed improved their physical skills.

In other studies, Shih [58] and Kırkgöz [80] investigated a hybrid learning approach supported by video lectures for an English speaking course. The study showed that the learners made noticeable improvement in their oral communication skills, and that they were satisfied with the blended learning model.

6) Student-Centred Learning: Most of the reviewed VBL studies followed a teacher-centred approach. Only 15% of studies have focused on student-centred learning [35][67]. These studies don't depend on teachers as content providers. They aimed at providing the space for students to be active participants in their learning environment, interact to build and construct knowledge, and get mutual support to make decisions using reflection and critical judgement.

C. Design

Several researchers in TEL have explored how to design effective VBL environments. Annotation and authoring tools are the most used design tools in the reviewed VBL literature.

1) Annotation Tools: Annotation means adding note, comment, explanation, and presentational mark-up attached to a document, image, or video [53]. In VBL, annotation refers to the additional notes added to the video without modifying the resource itself, which help in searching, highlighting, analysis, retrieval, and providing feedback [41]. Moreover, video annotation provides an easy way for indexing, discussion, reflection, and conclusion of content [49][66].

Colasante [45] examined the integration of a video annotation tool (MAT) into the learning and assessment activities of a third year class "Physical Education" course at RMIT University. This tool allowed learners to select and annotate parts of a video. These annotations are then used by students and teachers to discuss, receive feedback, reflect, and evaluate their learning and teaching practice. The results showed that MAT was effective for receiving feedback form teachers and peers. But, some issues regarding the quality of the collaborative input from peers were noted.

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2) Authoring Tools: A number of studies have developed a wide range of authoring tools for VBL content. The primary function of these authoring tool is to increase the interactivity with the VBL environment, thus engaging learners in the learning processe [73]. The following tools were used in various VBL environments:

- Synchronize lecture note: The aim of this tool is to synchronize a video stream with the presentation slide by means of video clip timing [73].
- Content summarization tool: This tool is able to extract summary information from lecture videos and provide it to the learners automatically [33] [55].
- Digital Video Library: This tool uses indexing to enable content-based search for a particular information of a video lecture [48].
- Discussion forum: A space integrated in the VBL environment where learners can discuss and share common interests or goals on a learning topic [30][32].

D. Reflection

There is an interest in using VBL to support teachers' and students' reflection on their teaching and learning activities [69][77].

1) Teacher Reflection: Video recording of the classroom lessons enables teachers to reflect on their teaching [20]. Teachers can record their own teaching, watch what they did in the classroom, think about it, and reflect on the performance using both individual and collaborative reflection [5][9].

Studies examined both individual and collaborative reflection. 85% of the studies on reflection in VBL noted that teachers prefer to reflect on their teaching performance with colleagues [9][20][46]. Similarly, Calandra et al. [5] and Calandra et al. [6] stressed that the teacher's reflective process should be collaborative where groups of teachers provide comments or feedback to each other. Several reflection methods were used, e.g., daily reflection, weekly reflection, and end of semester reflection [64][65].

Only 15% of studies examined self-reflection where teachers reflected individually on their teaching. Teachers used video-taped lesson analysis and wrote comments for self-reflection [14]. Likewise, Gainsburg, [35] implemented video annotation tools to scaffold, structure, and transform teacher reflection.

2) Learner Reflection: Recording classroom activities is also important for learners to reflect on their own learning experience, evaluate their performance, and get a clearer overview of their learning progress. Video recordings further help learners in revision prior to exams [31][69].

V. FUTURE VISIONS

In this section, we will present the future visions carried out from the critical analysis of the VBL literature. In the last few years, the expansion of new open VBL models, such as Massive Open Online Courses (MOOCs) and flipped classrooms has changed the TEL landscape by providing more opportunities for informal learners than ever before, regardless of their educational level, culture, location, age, income, and admission requirements.

A. MOOCs

MOOCs are leading the new revolution of TEL, by providing new opportunities to a massive number of learners to attend online courses from anywhere all over the world [75]. Different forms of MOOCs have been introduced in the MOOC literature. Siemens [27] characterize MOOCs into cMOOCs-based on a theory of connectivism, and xMOOCs by virtue of behaviorism and cognitivist theories with some social constructivism aspects as more institutional model, e.g., Coursera, edX and Udacity. cMOOCs enable learners to build their own networks via blogs, wikis, Google groups, Twitter, Facebook, and other social networking tools outside the learning platform without any restrictions from the teacher [26]. In xMOOCs, by contrast, learning objectives are pre-defined by teachers who impart their knowledge through short video lectures, often followed by simple e-assessment tasks (e.g. quiz, eTest) [70]. Recently, new forms of MOOCs have emerged. These include smOOCs as open online courses with a relatively small number of participants and blended MOOCs (bMOOCs) as hybrid MOOCs including in-class and online video-based learning activities [27].

In general, MOOCs require key stakeholders to address a number of challenges, including questions about hybrid education, the role of the university/teacher, plagiarism, certification, completion rates, and innovation beyond traditional learning models. These challenges will need to be addressed as the understanding of the technical and pedagogical issues surrounding MOOCs evolves.

B. Flipped Classroom

In the flipped classroom model, learners watch video lectures as homework. The class is then an active learning session where the teacher use case studies, labs, games, simulations, or experiments to discuss the concepts presented in the video lecture [10]. The flipped classroom is also an instance of VBL model that enables to save time in the classroom by discussing only difficulties, problems, and practical aspects of the learning course [7].

VI. CONCLUSION

VBL is a rich and powerful model used in TEL to improve learning outcomes as well as learner satisfaction. In this paper, we analysed the research on VBL published in 2003-2013. 67 peer reviewed papers were selected in this review. A cognitive mapping approach was used to map the conducted research on VBL into four main dimensions namely, effectiveness, teaching methods, design, and reflection.

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The following is a summary of the main findings in our study as well as aspects of VBL that need further research, according to each dimension.

A. Effectivness

The analysis of the VBL research showed mixed results in terms of learning outcomes in VBL environments. There is, however, a tendency that users of VBL environments rate interaction and learner satisfaction significantly higher than in traditional classroom environments. Despite these possible advantages, several aspects concerning effectiveness in VBL need further investigation: (1) what are the positive and negative attitudes towards using video lectures? (2) How can VBL motivate learners? (3) How can a MOOC as VBL environment personalize the learning experience for learners? This would enable learners to select the educational resources and the learning style that meet their characteristics best, thus increasing the effectiveness of the learning experience.

B. Teaching Methods

Educators use a broad range of teaching methodologies in VBL environments. These include collaborative learning, micro teaching, video summarization, video assessment, hybrid learning, and student-centered learning. Most of VBL implementations so far still follow a top-down, controlled, teacher-centered, and centralized learning model. Only, 15% of the reviewed research papers describe attempts to implement bottom-up, student-cantered approaches. Additional research is needed to investigate the benefits of new ways of VBL based on new learning concepts such as personal learning environments [1] and network learning [9].

C. Design

Several tools were used in VBL to increase interactivity, collaboration, and learners' satisfaction with the VBL environment. Annotation tools are utilized in searching, highlighting, analysis, retrieval, and providing feedback. To increase interactivity a number of authoring tools were used. These include lecture note synchronization and content summarization tools as well as video libraries and forums. Future research needs to find out how to design more open models of VBL such as MOOCs and flipped classroom.

D. Reflection

VBL facilitates teachers' as well as learners' reflection. Our study showed that teachers prefer to reflect on their teaching performance with colleagues rather than individually. And, learners think that videos have the potential to be used as a reflection tool. Future research is needed to investigate how learning analytics can help to better understand and improve reflection and awareness in VBL environments, such as MOOCs.

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