# Towards Greater Learner Control: Web Supported Project-Based Learning

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**ABSTRACT**

Project-based learning has been suggested as an appropriate pedagogy to prepare students in information systems for the realities of the business world. Web-based resources have been used to support such pedagogy with mixed results. The paper argues that the design of web-based learning support to cater to different learning styles may give students more control over the learning process. A case study approach was used to analyse an undergraduate information systems class in a French business school. The results show that while students generally believe they attained the class learning objectives, they react very differently to this pedagogy.

**Keywords:** Project-Based Learning, PBL, Case Study, Learning Styles, Online Scaffolding.

## 1. INTRODUCTION

Project-based learning (PBL) is a pedagogy that uses project work to drive learning. The project is designed to create a need to learn and so more fully engage students in the learning process (Railsback, 2002). Students must self-direct and self-regulate their learning to successfully complete the project.

PBL holds promise for information systems education. Project work prepares students to work in a professional environment where information systems are designed and developed as projects (Melin, Axelsson and Wedlund, 2009). PBL may also help students develop the necessary skills and knowledge for successful IT project management (Tynjälä et al., 2009).

In a PBL pedagogy, the teacher's role changes from that of instructor to facilitator and resource provider. Information technologies, such as multimedia presentations (Brush and Saye, 2008), shared electronic whiteboards and chat rooms (Savin-Baden, 2003), and online course materials (Kurzel and Rath, 2007) are such resources. The use of these technologies within a PBL course requires students to shift from a passive role as information receiver to an active role, making choices as to how best to generate, obtain, manipulate, or display information (Means and Olson, 1995). While the use of information technologies with PBL instructional strategies have the potential to enhance learning outcomes (Alavi and Leidner, 2001), successful use of technologies with PBL has proven problematic (Marx et al., 1997).

Web-based learning technologies would appear to be a promising complement to PBL. Online multimedia resources allow permanent access to information in a variety of forms. Instructional delivery can be adapted to different learning approaches and styles which could further enhance PBL learning outcomes (Kurzel and Rath, 2007). Little research has reported on the use of web-based learning technologies as a support for different learning styles in a PBL pedagogy.

Our study reports on a class where web-based learning technologies were used to support PBL. Our objective is to improve our understanding as to how students use these technologies in a PBL context.

The first section of the paper reviews previous research on project-based learning and the use of e-learning technologies to support different learning styles. Several research propositions are developed to guide our research. A case study research approach is then developed to examine how online resources are used by students in an information systems class to support project-based learning. The results are then presented and discussed. The limitations of the paper and future research directions are identified and conclusions are drawn.

## 2. PREVIOUS RESEARCH

In his review of previous project-based learning studies, Thomas (2000) explains that project-based learning has emerged from expeditionary learning (Udall and Mednick, 1996), postsecondary models of problem based learning in the health sciences (Boud and Feletti, 1997), and research in the cognitive sciences. It has been used in a variety of contexts, including history (e.g. Brush and Saye, 2008), literature (e.g. Jacobson and Spiro, 1994), science (e.g. Simons and Klein, 2007), economics (e.g. Mergendoller, Maxwell and Bellisimo, 2006), information systems (e.g.

Yip and Ghafarian, 2000), and accounting (e.g. Milne and McConnell, 2001).

Project-based learning can be defined as a course designed around a project. Projects are central to the curriculum. They should ideally be focussed on questions that lead students to central issues in a discipline, realistic, student driven, and involve students in constructive investigation (Thomas, 2000). Emphasis is placed on long term, interdisciplinary and student centred learning activities rather than short, isolated, teacher driven lessons (Railsback, 2002).

Students typically work on projects in small groups. The group's objective is to design and construct a product that meaningfully responds to a project brief provided by the class instructor. The type of product depends on the class objectives. It may be a marketing plan in an international marketing class (Hu, 2009) or a robotics prototype in a first year engineering class (Raucent, 2004). This product focus differentiates project-based learning from other forms of inquiry based instruction such as "problem-based learning." The focus in problem-based learning is typically the problem solving process itself rather than the production of any physical output.

Project-based instruction follows a constructivist approach to learning (Henze and Nejdl, 1998). Students construct their learning through project work. Prior experiences and knowledge are completed by self-directed use of learning materials and other supporting resources.

The learning process may be supported by a variety of different services, or "scaffolds." Scaffolding may take many forms including procedural guidelines (e.g. Greene and Land, 2000), student-teacher interactions, the provision of learning materials, and the use of computer based collaborative platforms (e.g. Collis, 1997). Information resources are particularly important to help students construct mental models, formulate hypotheses and work within the problem space (Reigeluth, 1999). The World Wide Web (Web) is increasingly used in PBL to provide multimedia resources such as articles, videos, text documents, sound files and animations.

The utility of web-based scaffolds is contingent on a learner's understanding of how the resource could be helpful (Greene and Land, 2000). Learning systems often integrate online resources that are not useful for task execution or lack a clear link to the problem solving process (Reigeluth, 1999). We believe that online scaffolding designs that support differences in student's approaches to learning may improve the utility of web-based resources. The education literature suggests that the quality of learning material is enhanced if the material is designed to take into account student's individual learning styles (Kramer-Koehler, Tooney and Beke, 1995; Rasmussen, 1998; McLoughlin, 1999; Riding and Grimley, 1999).

Learning styles are the different ways that adults and children think and learn (Litzinger and Osif, 1992). Numerous theories and models have been developed. Coffield, Moseley, Hall, and Ecclestone (2004) identified 71 different models of which they consider 13 to be major.

Kolb's (1976; 1984) experiential theory of learning and set of four learning styles was adopted for the present study as it is based on the same precepts of "learning by doing" as the project-based learning pedagogy. According to Kolb, learning is grounded in experience. It "is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it." (Kolb, 1984, pp. 38).

Kolb describes a four stage learning cycle where knowledge is created through the transformation of experience. The cycle may be entered at any stage but must be followed in sequence for learning to take place. The experiential learning cycle is reproduced in figure 1.

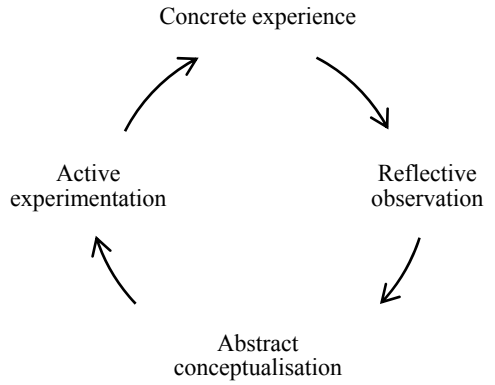


**Figure 1: The experiential learning cycle (Kolb, 1976)**

The cycle begins when an individual experiences something new ("concrete experience"). It may be a direct personal experience or an observed phenomenon. The first reaction is to reflect upon the new experience to determine how to best deal with it. This brings the individual into the second phase of the learning cycle, that of "reflective observation." Learners review their experience and reflect upon it. They may seek the opinions of others, compare their new experience with prior experiences or observe how others deal with the same situation. Learners then create concepts to integrate their observations into logically sound theories ("abstract conceptualisation"). Theories are then tested to see if learners can use them to make decisions and respond to the experiences encountered at the first stage of the cycle ("active experimentation"). This experimentation gives rise to new concrete experiences and the cycle begins once more. Learning is a continuous, iterative process.

Web resources may be provided for all four stages of the learning cycle. An editorial piece or case study from an online professional magazine may stimulate reflective observation on the experience of others. An online class that develops key constructs, concepts or models may help theory building. Work on projects in a PBL structured course provides students with the possibility to experiment and acquire concrete experience.

We expect students to select different types of online resources as they move themselves through their learning cycle to complete class deliverables. Our first research proposition can be expressed as follows:

P1: Students use all types of online resources to produce class deliverables.

A learner may enter the learning cycle at any stage. A learner's preference for one stage over another describes his or her learning style.

In Kolb's model, a learning style preference is the product of two variables. The first is the way individuals perceive or think about things. Some prefer to feel raw, concrete experience ("feel"), whereas others prefer to think about things as concepts and ideas ("think"). The second variable is the way individuals process the results of their perceptions. Some individuals will actively experiment to prove what they have concluded ("do") while others will prefer to observe or watch their environment for proof ("watch"). Preferences along each variable are conflicting. We cannot watch and do at the same time, for example. The product of these four choices (think or feel, and watch or do) creates four possible learning styles.

| Learning style | Preference |
|---|---|
| Divergor | Feel and watch |
| Assimilator | Think and watch |
| Convergor | Think and do |
| Accomodator | Feel and do |

**Table 1: Kolb's four learning styles (Kolb, 1976)**

Students that show a preference for thinking over feeling (Assimilators and Convergors) have been found to perform better using web-based learning than instructor based learning (Hu et al., 2005). Manochehr (2006) found that while learning styles were irrelevant for instructor based classes, Assimilator and Convergor learning styles performed better in a web-based learning environment.

We expect students that show a preference for abstraction (Assimilator and Convergor learning styles) over the acquisition of concrete experience (Divergor and Accomodator learning styles) to more favourably perceive web-based learning and to perform better in a web supported PBL course. Our second and third research propositions can be expressed as follows:

P2: Students with Assimilator and Convergor learning styles perceive online resources as more useful to their learning than students with Divergor and Accomodator learning styles.

P3: Students with Assimilator and Convergor learning styles will perform better using a web-based PBL course design than students with Divergor and Accomodator learning styles

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We will now outline the research design that was used to test our research propositions.

## 3. RESEARCH METHODOLOGY

A case study research design was adopted as the most appropriate for our study. We will now present the case context and then the data collection techniques employed.

### 3.1 Case presentation: IS 101

A Project-based learning approach was adopted to instruct a second year undergraduate introductory information systems class (IS 101) in a French business school. 382 students were enrolled in this business school core course. Instruction was delivered in French.

The objective of IS 101, as stated in the class syllabus was to "develop the necessary know-how to propose, study, describe and plan an IT based innovation." The class objective had been changed to reflect the product focus of the new PBL pedagogy.

The project was central to the organisation of the class. Students were randomly assigned to groups of three. The project objective was to identify and build a web site to improve the way a company operates. Two fictional case descriptions were provided for students to choose from.

| Project phase | Deliverable submitted |
|---|---|
| A: Design phase | A: Conduct a feasibility study of the project |
| B: Development phase | B1: Describe the functional needs and the environmental constraints of the system |
| | B2: Develop and publish an online demonstration version of the information system |
| C: Implementation phase | C: Devise a diffusion strategy and web marketing plan for the project |

**Table 2: List of deliverables due by project phase**

| Guideline | IS 101 project |
|---|---|
| PBL projects are central, not peripheral to the curriculum | All class activities were organised around project work. |
| PBL projects are focused on questions or problems that "drive" students to encounter (and struggle with) the central concepts and principles of a discipline | Deliverables oriented students towards key disciplinary issues. |
| Projects involve students in a constructive investigation | Deliverables required the learning and application of new skills. Students were required to use online resources to acquire the skills necessary to complete the project. |
| Projects are student-driven to some significant degree | Students had to imagine, describe and build an IT based information system within the context of the case description. |
| Projects are realistic, not school-like | Students were free to choose from one of two project briefs. The briefs were however presented in the form of a school case study. Students were encouraged to use real-world data (e.g. financial data). |

**Table 3: Compliance of the IS 101 project to PBL project guidelines (Thomas, 2000)**

Work on the project was organized to follow a simplified three phase work plan: design, development and implementation. Groups submitted a product or deliverable at the end of each phase. The phases and corresponding deliverables are presented in table 2.

At the end of class, each group submitted a final report that accounted for 50% of class grade. The final report was a summary of deliverables A, B1, B2 and C. Students were forewarned that the final report would not be graded if deliverables were submitted late or were of poor quality. A final individual exam based on all the subjects covered and the learning resources provided during the class accounted for the remaining 50% of class grade.

The project generally follows Thomas's (2000) guidelines as summarized in table 3.

In order to successfully complete the project, students were required to follow online courses, engage in group work, and participate in scaffolding classes. A timeline of class activities is presented in figure 2.

A series of online classes were made available to provide students with reference materials to complete deliverables. The list of online classes is presented in table 4.

The organisation of different scaffolding services was built around Kolb's experimental model of learning (Kolb, 1984). Online resources, such as video and professional magazine articles provided material to observe the experiences of others. Online classes supported conceptualisation and theory building. Scaffolding classes and project work allowed for testing of that theory through active experimentation and the acquisition of new concrete experiences.

A class web site was developed to host all online resources. The home page provided course news, a calendar and access to four thematic areas. The first area gave direct access to online classes. The second area presented deliverable specifications and allowed for uploading of deliverables. Groups could also consult the online evaluation of their work via this interface. The third area listed all documents that could be downloaded, such as scaffolding class presentations, or lists of key points for online classes. The fourth area enabled students to ask and find answers to questions about the course in general or more specifically about the case work.

The role of the scaffolding class was to consolidate student learning. Each scaffolding class was planned after the corresponding deliverable due date. Deliverables were corrected prior to class by the instructor. This was done to give groups feedback on the quality of work submitted and in so doing encourage discussion during class time. The instructor was also able to use the scaffolding class to focus on blocking points and mistakes students had made. Groups were encouraged to use scaffolding classes to improve the quality of their final report. These 1 ½ hour instructor-led classes involved a summary of key points and additional practical work (e.g. cases and exercises) on comprehension difficulties. Three 1 ½ hour scaffolding classes were planned during the course.

### 3.2 Data collection

Data was collected in three different ways. The first source of data was student online activity. All connections to pages and files on the class web site were recorded to a log file to measure actual system use. Data was also collected via an online questionnaire distributed at the end of the class. The questionnaire items measured student's perceived utility of online resources, perceived attainment of class objectives and learning style. Out of the 382 students enrolled in the class, 310 completed questionnaires were returned. Only 84

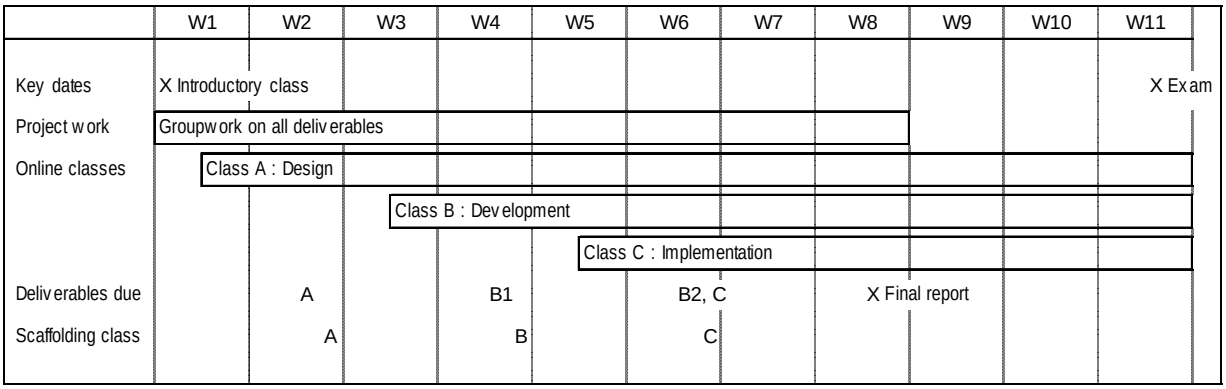


**Figure 2: Timeline of class activities**

| Project work | Online class |
|---|---|
| Feasibility study | Evaluate the feasibility of an IT project |
| | Business and the Internet |
| Functional analysis and web site | Functional analysis of an IT project |
| | Organise and plan an IT project |
| | Build and publish a web site |
| Diffusion strategy and web marketing plan | Diffusion of innovations |
| | Introduction to web marketing |

**Table 4: Online classes by project deliverable**

students provided learning style information. Completed questionnaires were anonymous. Administrative records were used as a third data source to measure academic success. The measures are presented below. Variable names are provided in brackets.

### 3.3 Measures

**3.3.1 Online resource use:** Systems use was measured by counting the number of logins to the web site home page and access to online resources. Every time a page or a file was requested from the web server, it was recorded as a "hit."

**3.3.2 Utility of online scaffolds:** The perceived usefulness of online resources ("Web utility") was measured using a self reported question. Students were asked to rate how well online classes aided the learning process. Reponses were provided along a 5 point likert-type scale ranging from "not at all" to "absolutely."

**3.3.3 Goal achievement:** Four measures of goal achievement were used. Three concerned perceived skills acquisition in each of the course modules, and one related to academic achievement.

Students were asked on three questionnaire items to assess whether they could design ("Design objective"), develop ("Develop objective") and implement ("Implement objective") an information system in a professional situation. Responses were given along a five point likert-type scale, from "not at all" to "absolutely."

Academic achievement ("Grade") was measured using data from academic records of student grades on the final exam.

**3.3.4 Learning styles:** Learning styles were measured based on Kolb's typology and learning-style inventory (Kolb, 1976; Kolb, 1984). The French language ISALEM-97 instrument was used (LEM-ULg, 2007). Students were presented with twelve different real world and school situations. For each situation they were asked to rank four possible reactions ranging from "Absolutely me" to "Rarely me." Rankings were cumulated to produce one score for each learning style. The scores were then combined to give a student's preferred learning style.

Table 5 provides descriptive statistics and the zero-order correlation matrix for the quantitative variables measured.

## 4. RESULTS

We will now present the results of our study. We begin with an analysis of online resource use before looking closer at perceptions of goal achievement and scaffolding utility.

### 4.1 System and online resource use

Platform use was directly measured from server log files. There were 11588 recorded individual logins to the home page and 6313 hits to online resources. Student's logged in on average 30.3 times to the platform over the 11 weeks of the course. The range of logins varied however, with no recorded connection for 11 students.

Home page connection patterns were plotted over time. They are presented on the chart in figure 3.

The three peaks correspond to connections leading up to the deadlines for deliverables A, B2, C and the final report. It would appear from the chart that students used online resources to work on their projects. Interestingly, there was no peak prior to the due date for deliverable B1. This may be because the deliverable was due during a holiday period. Groups may have managed their work differently than for other deliverables.

Three different types of online resources were provided for each class. Each resource type corresponds to one of the first three stages in the experiential learning cycle: acquisition of concrete experience ("experience"), reflection on experiences ("reflection"), and theory building ("conceptualisation"). No online resources were provided to support the fourth stage of the learning cycle involving testing theory through active experimentation. Project work was considered sufficient experimentation for this phase.

Use of online resources was plotted over time for each project phase to explore our first research proposition and see if all resources were used to pursue work outcomes. The resulting chart is presented in figure 4.

The peak in resource use occurred around the date of the deliverable A with a second peak prior to the final exam. There was little activity when the final report was due in week eight. All three media types appear to have been used together to pursue work outcomes. Resources supporting conceptualisation activities however were used more intensively than those for other activities. The main resources consulted for group work during the design phase of the project were those supporting abstraction and conceptualisation activities. This difference in resource use is statistically significant ($\chi$=36.9, df=20, p=0.013).

Resource use over time for the development phase is presented in figure 5. There is a statistically significant difference in resource use over the 11 weeks of class ($\chi$=37.1, df=18, p=0.005). More hits were recorded to resources supporting reflection activities than for other activities around the due date for deliverable B1. This may be explained by the high number of connections to a document presenting different formats for functional specifications. Theory building resources were the most consulted for deliverable B2 and for exam preparation.

| | Variable | Range | Min | Max | Mean | SD | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Design objective | 1-5 | 1 | 5 | 3,43 | 0,87 | 1 | | | | |
| 2 | Development objective | 1-5 | 1 | 5 | 3,61 | 0,74 | 0,48** | 1 | | | |
| 3 | Implement objective | 1-5 | 1 | 5 | 2,95 | 0,62 | 0,43** | 0,47** | 1 | | |
| 4 | Web utility | 1-5 | 1 | 5 | 3,35 | 1,06 | 0,18** | 0,13* | 0,11* | 1 | |
| 5 | Grade | 0-20 | 0 | 19 | 6,39 | 3,67 | 0,05 | 0,06 | 0,03 | -0,10 | 1 |

**Table 5: Descriptive statistics and correlations of the quantitative variables at test**
**(***Significant at .05 level ** Significant at /01 level)

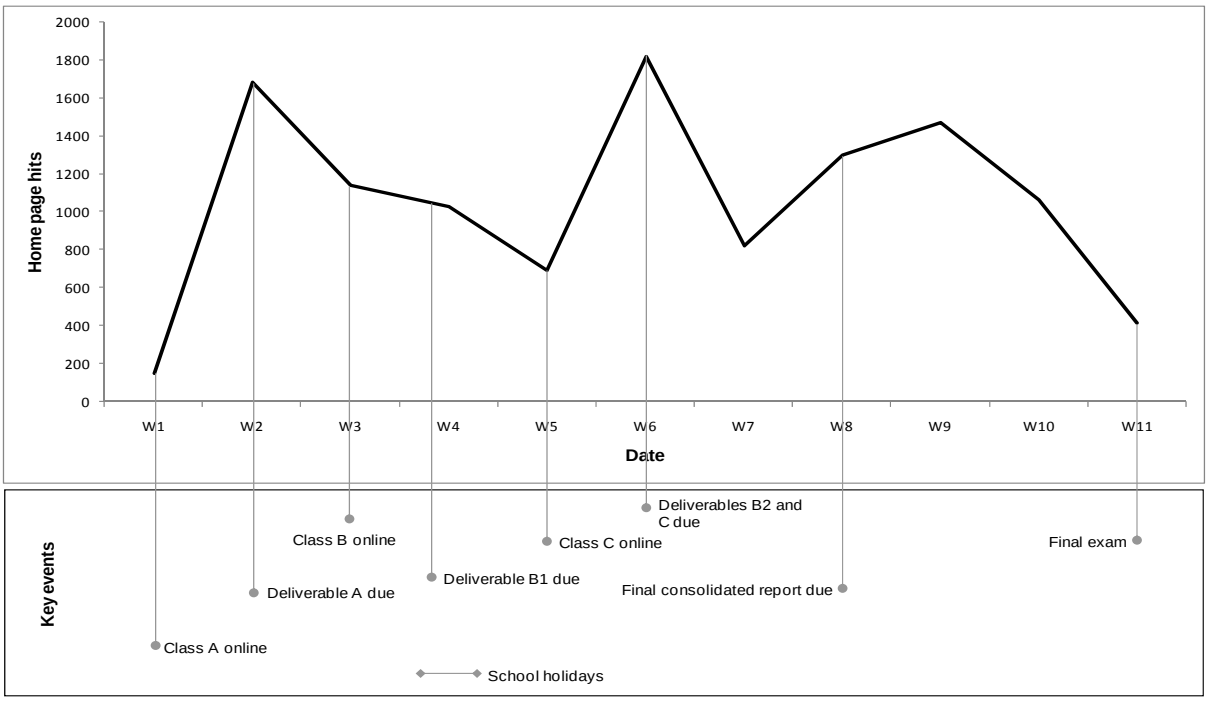


**Figure 3: Chart of home page connection patterns**

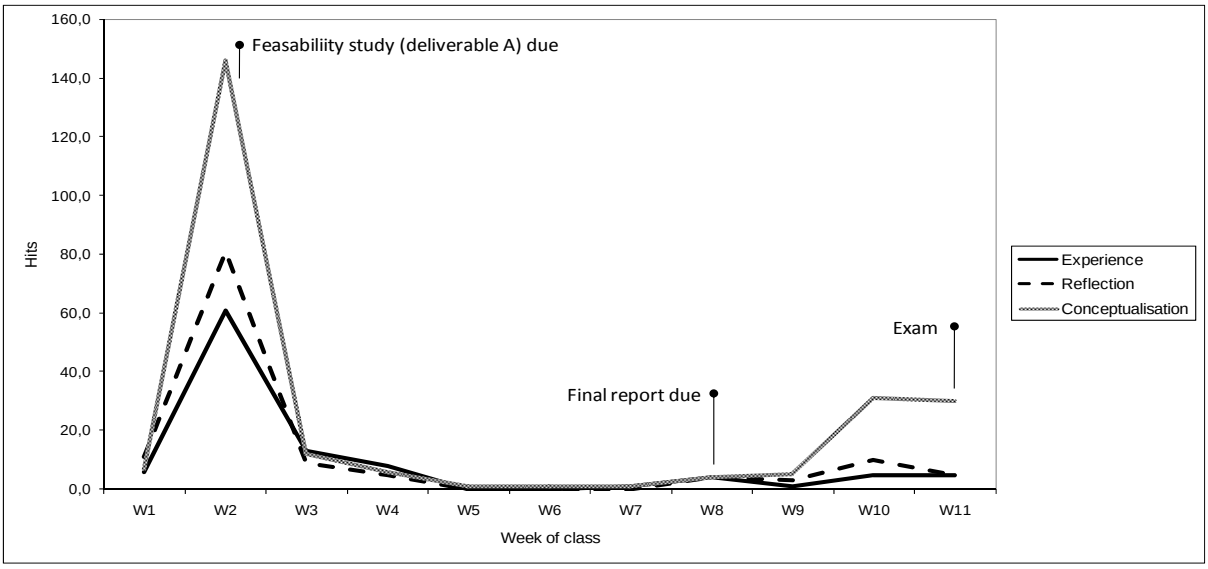


**Figure 4: Patterns of online resource use for the design phase (phase A)**

All three resource types were used by students to work on the deliverable C, the diffusion strategy and web marketing plan. More hits were recorded for theory building resources. The pattern of resource use over time for the implementation phase is presented in figure 6.

There are three peaks in connection patterns, one for the deliverable C, a second for the preparation of the final report and a third for exam preparation. The differences in resource use are statistically significant ($\chi$=40.6, df=12, p=0.0001).

All three resource types were used together throughout the course to produce work outcomes. This result supports our first research proposition. There was however a preference for theory building resources over other resource types during each phase.

One explanation for the differences in use of online resources is individual learning styles. We will now examine how the perceived utility of online resources varied according to student learning preferences.

**4.2 Usefulness of online scaffolding for learning**

The relationship between learning styles and the perceived utility of online scaffolding was tested for the subset of 84 students who provided learning style information.

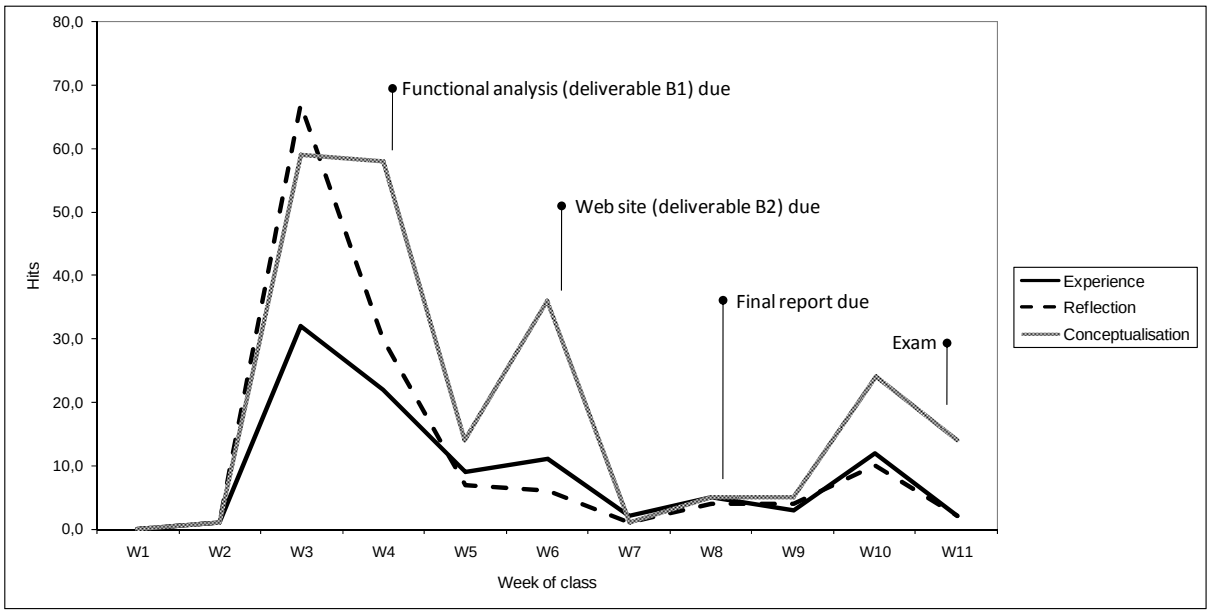


**Figure 5: Patterns of online resource use for the development phase (phase B)**

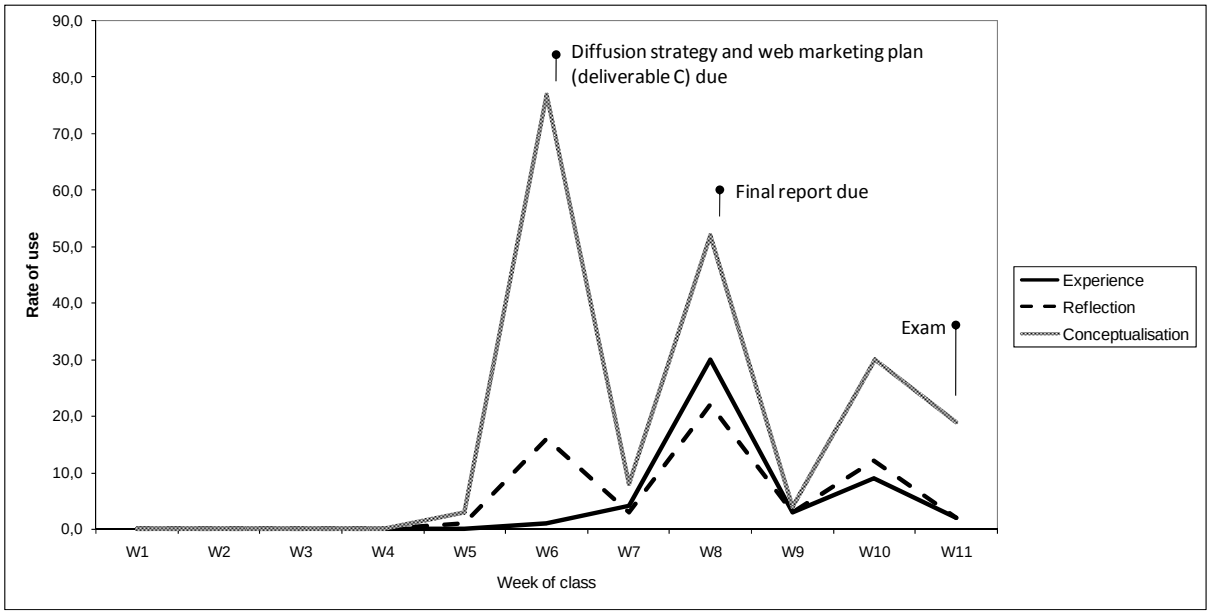


**Figure 6: Patterns of online resource use for the implementation phase (phase C)**

Kruskall-Wallis test was run on the data. It is a non parametric one way analysis of variance that has proven robust for small sample sizes. The results are presented in table 6.

There was no significant relationship between learning styles and the perceived utility of online resources. This result is contrary to expectations and invalidates our second research proposition. Students with a preference for abstract conceptualisation to concrete experience do not perceive online resources as more useful than other students.

### 4.3 Class performance and learning style

We expected students with Assimilator and Convergor learning styles to perform better using a web-based PBL course design than students with Divergor and Accomodator learning styles.

A Kruskall-Wallis test was run on the subset of 84 students who provided learning style information. The results are presented in table 7. Academic success and perceptions of goal attainment did not vary according to learning style

| Variable | K | df | p-value |
|---|---|---|---|
| Web utility | 1.47 | 3 | 0.69 |

**Table 6: Test for differences between perceived utility of online scaffolding and student learning styles. (Kruskall-Wallis test, n=84)**

| Variable | K | df | p-value |
|---|---|---|---|
| Design objective | 2.75 | 3 | 0.34 |
| Development objective | 0.52 | 3 | 0.91 |
| Implementation objective | 0.61 | 3 | 0.89 |
| Exam grade | 1.05 | 3 | 0.79 |

**Table 7: Test for differences between performance and learning styles. (Kruskall-Wallis test, n=84)**

This result is contrary to that expected and invalidates our third research proposition. Students with Assimilator and Convergor learning styles do not perform better using a web-based PBL course design than students with Divergor and Accomodator learning styles.

### 4.4 Post hoc Analysis of Student Comments and Suggestions

Post hoc analysis of student suggestions and comments concerning the organisation of the class was undertaken to help interpret our results. This data was collected via the online questionnaire distributed at the end of the course (see section 3.2).

Students were invited to choose their preferred class structure among four alternatives: 100% instructor-led classes, 50% online and 50% in class instruction (50/50), 100% online classes or some other organisation. The results were split. One half of students (50%) prefer a 50/50 organisation, while 40% of all students prefer 100% instructor-led classes. Very few students (2%) said they would prefer entirely online classes.

Students were invited to comment their answers and suggest improvements for the organization of the class. Of the 310 returned questionnaires, 108 students provided a suggestion or a comment. A grounded analysis approach (Glaser and Strauss, 1980) was employed to construct an eight item coding scheme for textual data. All textual analysis and categorization was first undertaken in French, the language of instruction. Category names were later translated to English by the author. The results are presented in table 8.

Students suggested that online classes should remain a support for classroom activities. Stand alone online classes were considered unclear, time consuming and less interactive than instructor-led sessions. There was a demand for more hands-on instructor-led classes.

One explanation for these comments may be the practical nature of the pedagogy. Students may have been seeking the most efficient way to learn the necessary skills to produce the different deliverables. Integrating the different online learning resources throughout the learning cycle was time consuming and difficult. Instructor-led classes were perceived to be more efficient.

> *"If we took all online classes to the letter (read articles, follow slide shows ...) it would take more than one and a half hours. A 1 ½ hour face to face class would be more effective." [Student A]*

Instructor-led classes may afford more opportunities for feedback as students move through the learning process.

> *"Even if Internet based courses seem a very good idea to begin with, in the end this is not the best solution. Indeed, this is a little known subject (not like marketing, finance) and so online courses do not allow us to really exchange on what it is all really about, how we will be able to use it ... The rare face to face classes are not enough." [Student B]*

> *"It is easy to learn with a course in the classroom. You can ask questions to the teacher ..." [Student C]*

The next section interprets our results in light of our research propositions.

## 5. DISCUSSION

Our research was motivated by a need to better understand how online resources could be provided to scaffold project-based learning. Based on Kolb's experiential model of learning (Kolb, 1984) students were expected to need and to use a variety of online resources to move through their learning cycle. Our results support this conjecture. Students used all three types of online resources – experience, reflection and conceptualisation – to complete their project work. Online scaffolding resources should be designed to support the different stages in the learning cycle.

There were statistically significant differences in resource types used during each of the three project phases. Students tended to use theory building (conceptualisation) resources more than other online resources. One explanation may be efficiency considerations. Using online resources generally required a greater investment than the institutional norm of 1 ½ hours of class time per week. Students may choose to use resources closest to traditional classroom instruction. Theory building resources were often online animated slide show presentations with audio commentary. This is a familiar teacher centred delivery of key learning points. This result is similar to that of Beasley and Smyth (2004) who found that students often revert back to learning methods and techniques that they are most familiar with.

We expected students with a preference for abstract conceptualisation over concrete experience to perceive online resources as more useful to their learning than other students. However, there is no significant relationship between the perceived usefulness of online resources and learning styles. Our second research proposition was not supported by our results. One explanation may be that as online resources were designed to scaffold the different phases of the learning cycle, they adequately supported different learning styles. A student with a preference for concrete experience over abstract conceptualisation, for example could enter the cycle by reading an editorial or a case study to build an understanding from the experiences of others.

We did not find support for our third research proposition. We expected Students with Assimilator and Convergor learning styles to perform better than students with Divergor and Accomodator learning styles. However, there is no significant relationship between student perceptions of goal attainment and learning styles or between student academic achievement and learning styles. Students exhibiting Assimilator and Convergor learning styles did not attain higher grades or report higher skills development than other students.

| Category | Occurrences |
|---|---|
| 1. Online classes should remain a support for classroom activities | 23% |
| 2. More hands on scaffolding needed | 19% |
| 3. Online classes lack clarity | 15% |
| 4. Difficulties with time and technical issues | 14% |
| 5. Instructor-led classes are more interactive | 13% |
| 6. Give class prior to doing work | 13% |
| 7. Online classes and PBL combination works well | 4% |

**Table 8: Student Comments for Class Improvements**

The possibility for a student to enter the learning cycle at his or her preferred phase may explain this result. Each learning style type was able to work directly and perhaps predominantly on preferred activities. The research methodology could be improved in future studies by collecting data on student satisfaction with the different resources. In so doing, we could more finely study learning style preferences for supporting resources.

Student satisfaction with online resources for PBL support was mixed. Two fifths of all students wish to return to face to face instruction. Students made clear from their comments that they would prefer instructor-led classes and hands on learning activities prior to deadlines. This result is interesting as it is in conflict with the constructivist pedagogy which underlies project-based learning. It would be interesting to consider in future research student expectations of the pedagogy, as well as habits reinforced by the way other subjects are taught within the institution.

One in two students considered web-based resources and face to face classes to be complementary. Instructor-led classes are seen as necessary to allow feedback and allow for the interactivity that is perceived as lacking in online resources. Students appear to have difficulties adapting to a less interactive medium without the habitual feedback present in a classroom (Tekinarslan, 2004). Further research into how best to accompany students from a classroom to an online environment is needed.

There are several limitations to our study. The first concerns the low number of returned learning style questionnaires. While the statistical procedures employed have allowed us to test our research propositions, there has been a significant loss of data.

A second limitation concerns the organisation of the different IS 101 class activities. Instructor-led scaffolding classes were run after deliverables had been submitted. Some students expressed frustration with the pedagogy and would have preferred taking classes prior to submitting work. Such negative reactions to the pedagogy may influence perceptions of goal attainment and motivation to use online resources.

## 6. CONCLUSION

Our study looked at how students use web-based resources during a 11 week undergraduate business school course in information systems following a project-based learning pedagogy. Our findings indicate that while web-based resources are considered useful, students have difficulty replacing face to face instruction.

The key issue was not, however, the dichotomous choice between online and in class instruction but rather how we can build online learning environments supportive of project-based learning. Our research highlights, albeit in a preliminary way that project-based learning resources should be provided to support the different stages in a student's learning cycle.

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## APPENDIX 1

In a professional situation I believe I could design or propose a new information technology project.
Not at all – No – I don't know – Yes – Absolutely

In a professional situation I believe I could write the functional specifications and project manage a new information technology project.
Not at all – No – I don't know – Yes – Absolutely

In a professional situation I believe I could promote and implement a new information technology project.
Not at all – No – I don't know – Yes – Absolutely

If you were to take a similar class, what would be the most appropriate organisation?
100% instructor-led class - 50% online and 50% in class instruction - 100% online classes - Some other organisation.

Do you have any comments or any suggestions to improve this class


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