Design Issues for a Scenario-Based Learning Environment
Technical Report

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Revision History

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Document Purpose

Abstract

This document outlines my thinking on the design of a scenario-based learning environment. The material presented falls into two distinct categories. These are presenting work completed so far and presenting current thinking on the design. As such, some of the material is based on experience over a number of years of using the approaches described and some is very tentative and needs further development.

The nature of a learning environment raises issues in many domains. These include educational issues and technical implementation issues. Although I endeavour to highlight the domain of issues, some of the boundaries are not always clear. Structure of the environment is impacted by the pedagogical techniques assumed or used.

Intent

This report has been prepared to review my thinking on the design of a scenario-based learning environment. It is not a system design document in the sense of presenting the design of a piece of software. Rather it looks at the issues of designing such an environment in the context of educational theory and the implications on the design of the environment.

Many of the ideas presented in this document are still in their foundational stages. Consequently, a number of open questions will remain in terms of the design. Other issues will be raised as potential areas for research.

The design of the environment is a vehicle for a number of research projects. These projects relate to issues of learning theory, online learning environment technical design issues, and issues with respect to the software development process. All of these possible perspectives will be touched on in this report.

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Introduction

Scenario-based learning

What is scenario-based learning?

In scenario-based learning, the learner is presented with a learning situation and a range of resources that can be used. In the perspective that I am using, the scenario establishes an environment in which there are a number of tasks to be completed and opportunities for learning presented. The scenario establishes a context for the learning (Thompson, 2003a) and provides specific problems that need to be solved.

An introductory scenario

You enter the reception area for Competitive Cycles Corporation. It is your first day as a trainee programmer. You are greeted by a smiling receptionist and asked to wait in the reception for the Systems Development Manager.

You move over to the comfortable seats in the waiting area. On the coffee table are product brochures, a document on the company's history, and the annual report. There are also some cycling magazines. One has a feature article on Lance Armstrong, the winner of the last five Tour de France events.

After a short period, the manager arrives. The manager quickly outlines the plan for the day and takes you on a tour of the software development facility. There are small groups working on projects in different workspaces. The manager invites you to observe and ask questions at any time.

At the end of the tour, the manager takes you to a coffee area adjacent to one of the workspaces. It has similar comfortable chairs to the reception area. It also has a coffee table with materials about the company and its products. There are also, what appears to be a number of toys on the table or at the edge of the area. You are invited to make yourself a coffee or some other drink.

The manager makes a coffee and takes a seat. Once you sit down, the manager begins to explain that your training will be primarily on the job. The company uses small software development teams comprising two to ten developers and a person who is the customer for the software under development. Each team starts its day with a short stand up meeting where progress from the previous day is discussed and objectives for the day are finalised. During this time, members of the team may request help from other team members or volunteer to pair with another team member on their task.

New trainees are assigned to a team and are given as part of their normal work role, the task of training. Most of their tasks will be related to the development of one of the company's systems but other tasks will be created that can be used to cover any special training needs. The manager says that in the stand up meetings, you will be given an opportunity to request training in any area that you think might be appropriate or a staff member might raise an area in which they would like to work with you on at some point in the day. If you suggest an area then a team member will volunteer work with you. The manager says that you may come and see him at anytime to discuss issues.

As the manager talks, the six others from the adjacent workspace join you in the coffee area. Although each of these organise their own coffee, none of them take a seat. They wait for the manager to complete his discussion with you, which is

signalled by the manager standing. The manager introduces you to them as the team to which you have been assigned.

As the manager leaves, the team begins to ask you about your background and explain the current project. They then hold their stand up meeting with one team member offering to be your minder for the day.

The discussion is very short and the team quickly forms pairs and moves into the team's workspace. The workspace is an open area with four workstations in the centre of the room so that pairs can work at them. A whiteboard is on one wall and is covered in small post it notes. Beside the whiteboard is a table with post it note pads and a bookcase of reference texts. Adjacent to the coffee area is a small area partitioned off. Your minder points it out and says that if at anytime you need some time on your own, you can go there.

Your minder explains the first task and …

Interactions

This scenario lays an environment in which the learner will work. In the scenario, a number of specific objects have been mentioned. These objects would be provided within the scenario-based learning environment (e.g. the information about the company and its products or the magazines). The learner should be able to pick these up and read them at any time as they move around the environment.

There is also the potential for the learner to interact with the environment such as asking the characters in the environment questions. Using a paper-based description, such interactions are difficult. Even in an online environment, allowing for the possible range of interactions can also prove difficult.

Type of scenario

The scenario that I have presented makes the assumption that learner will enter the environment as an apprentice (Lave et al., 1991). They will join a community of practice (Wenger, 1998) in the field of software engineering. Participation in this environment will allow them to observe other practitioners and to develop their own skills at completing the software development tasks. The scenario is designed to encourage them to learn more than the tools and techniques of software development. It should encourage the learner to integrate into the culture of the environment.

Structure of a paper-based on scenario-based learning

Overview

Introduction

This chapter discusses how a paper can be structured to use scenario-based learning. The structure discussed here is based on a paper-based model (Figure 1) initially developed for distance learning papers at The Open Polytechnic of New Zealand (Thompson, 1997; Thompson, 1998; Thompson, 1999). Some adaptation has been made to try and translate to classroom teaching (Thompson, 2003a).

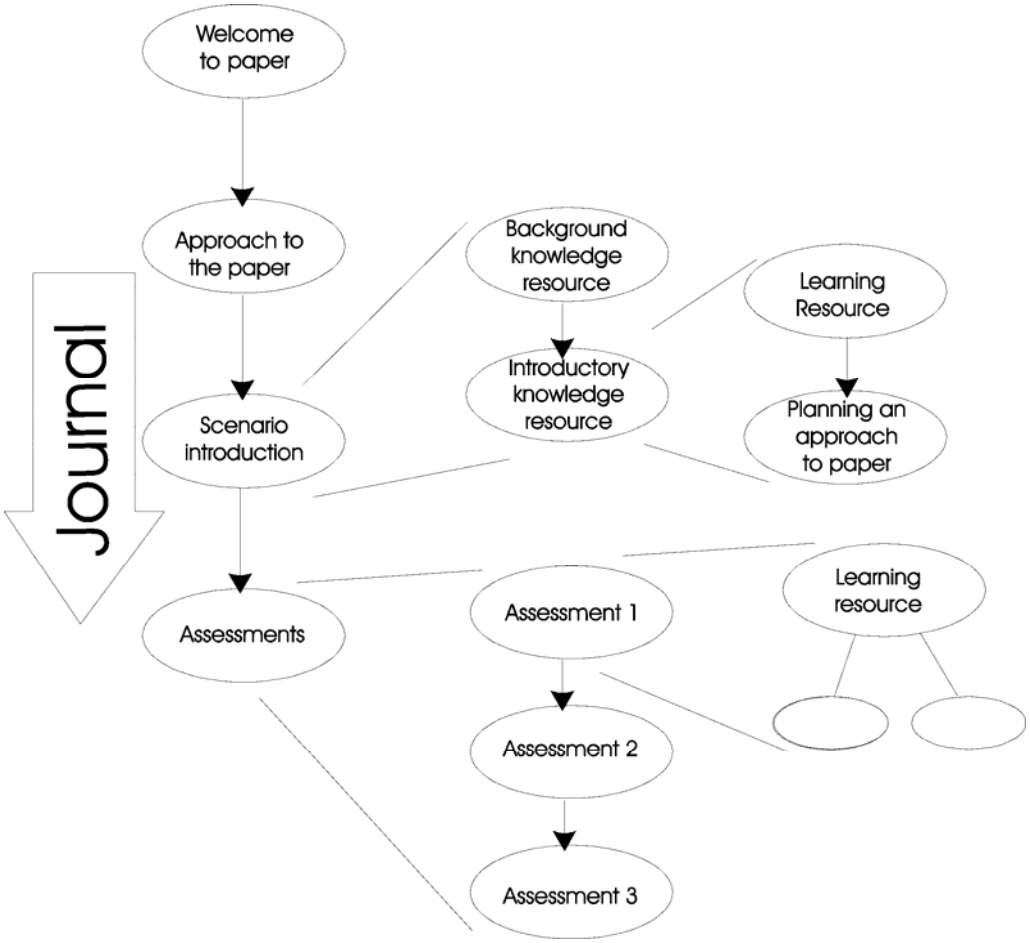


Figure 1: Structure of a scenario-based learning paper

Primary scenario

The primary scenario provides a flow and direction for the learners study. The primary scenario might comprise an initial scenario introduction, an opportunity to review background knowledge (a formative assessment), a series of summative assessment tasks, and a final summative assessment task or project usually an exam.

The primary scenario isn't one dialogue. Rather it is a series of scenarios that flow on from each other and draw the learner deeper into the subject under study. These scenarios focus on drawing together a number of areas of knowledge, skills, and techniques that the learner will cover in the supporting learning scenarios.

Initial scenario introduction

Above, in "An introductory scenario" (see page 5), an example of part of an initial scenario introduction is illustrated. This scenario provides an overview of the context in which the learning will take place. The key features of the initial introduction is that it should

1. provide an overall context for the learning,
2. capture the attention of the learner,
3. set an initial challenge, and
4. provide access to supporting resources.

In providing the overall context for the learning, the material to be learnt is given relevance and significance. It moves out of being a memorise and recall focus and into at least the application level of cognitive skill. The learning should be seen as helping complete the objectives of the initial scenario.

This part of the scenario should also highlight the assumed background knowledge or skill level assumed for the paper. This might be achieved through highlighting prerequisites or through the setting of tasks designed to validate background knowledge or skills.

There is a danger that the learning will be seen as only skill-based. To foster the full range of cognitive skills, careful crafting of scenarios is required. The crafting of scenarios is beyond the scope of this document.

Scenario background

Resources are designed to provide additional information about the organisation, its products, and the environment in which it operates. Part of the objective of these documents is to foster an understanding of the community culture into which the learner is entering. These help to further develop the context of the scenario and add realism.

Some of these resources may also provide background material for summative assessment tasks and for other learning resources. The learner may be directed to some of these resources during their involvement in the learning environment.

Summative assessment tasks

The summative assessment tasks should be written in the context of the initial scenario introduction. The learner should see these as naturally flowing on from that scenario and from each other. Together these build the primary scenario used in the paper.

The focus of these tasks is on the assessment of the learning outcomes for the paper. They also serve the purpose of driving the required learning. Consequently, these scenarios should point the way to the learning resources that will help build the knowledge and skills that the learner requires.

How to implement the linkage between an assessment task and learning resources is open to further investigation. Some discussion of possibilities will be examined in "A learning resource library" (see page 15).

Structurally, the summative task could be considered as the learning scenario of a learning resource. Each learning resource that is relevant to the summative assessment task could be regarded as the activities for the task. In the paper-based implementation, we simply listed all the relevant learning resources in the assessment task specification. In an online learning environment, the learning resources are part of a learning space and the system could present an appropriate

range of resources based on the learner profile and the nature of the summative assessment task.

Learning resources

A learning resource is focussed on guiding the learner to a particular learning outcome. It is a combination of reference material, guided instruction, and formative / self-assessment.

The detailed structure is discussed in Learning Resource (page 17). The structure used so far has included an opening task or scenario, the criteria for accessing successful completion, background knowledge requirements, workplace relevance, references, learning activities and feedback on those activities, and primary task or scenario feedback. The objective was to make the learning resources self-contained so that the student could work on them with minimal input from a tutor.

Presenting the task first maintains a scenario-based approach to learning and allows the learner to assess whether they need to complete the learning activities of the resource. It should be noted that this is not seen as a conventional approach to instructional design. A conventional approach is to present the readings or material to be learnt followed by a series learning activities or assessment tasks.

An online learning environment

Overview

Introduction

In a distance-learning context utilising a paper-based version of the materials, it was difficult to hold back feedback to learning tasks until the student had completed the learning task without increasing the cost to the student and the institution. In the classroom setting, it is easier to provide the feedback after the student has made a reasonable attempt at resolving the problem.

An online learning environment can address these issues so that feedback is more dynamic and based on the responses and progress of the student. How the system might assess a student response to a task as being reasonable would depend on the nature of the task and the way that the student would submit their response. However, there is potential for greater flexibility in the interaction.

Learner perspective

When looking at a scenario-based online learning environment, an overriding consideration is the learner's perspective of the environment. Part of the objective of using a scenario-based learning approach is to provide a context for learning. In the proposed environment, this should model that of the learner entering the environment as an apprentice in the subject area.

In this context, the system has to model the processes of the subject area and engage the student in those processes and the community of learning that surrounds those processes.

At the same time, the environment should not overwhelm the learner with options but provide the learner with sufficient facilities to be able to locate the type of assistance that the learner needs. Figure 2 is a screen form design draft for the general environment. The intention of this layout is to provide the learner with access to the different features of the environment while still enabling a degree of contextual relevance through the menus on the left hand side of the screen. A secondary element is to enable the learner to provide feedback to the system through the assistance / feedback area, to have some ability over the way the material is displayed through the layout options, and to be able to navigate through the environment through the navigation bar.

It is envisaged that feedback from the student would update the student model within the system and would allow the system to adapt the quantity of material presented and the suggested paths forward. This is an area where more research is required.

Component parts

Figure 3 endeavours to provide an overview of the environment. The components are seen as the current structure for a scenario-based learning environment. As well as the primary scenarios, the system would include a resource library or learning space containing the learning resources, a work area, and a discussion area. These components will be explained in more detail in the following sections.

Although these are seen as the required components at this time, it is envisaged that the system should be easily extended through the addition of new components and user interaction modules (see Software Architectural Issues on page 28).

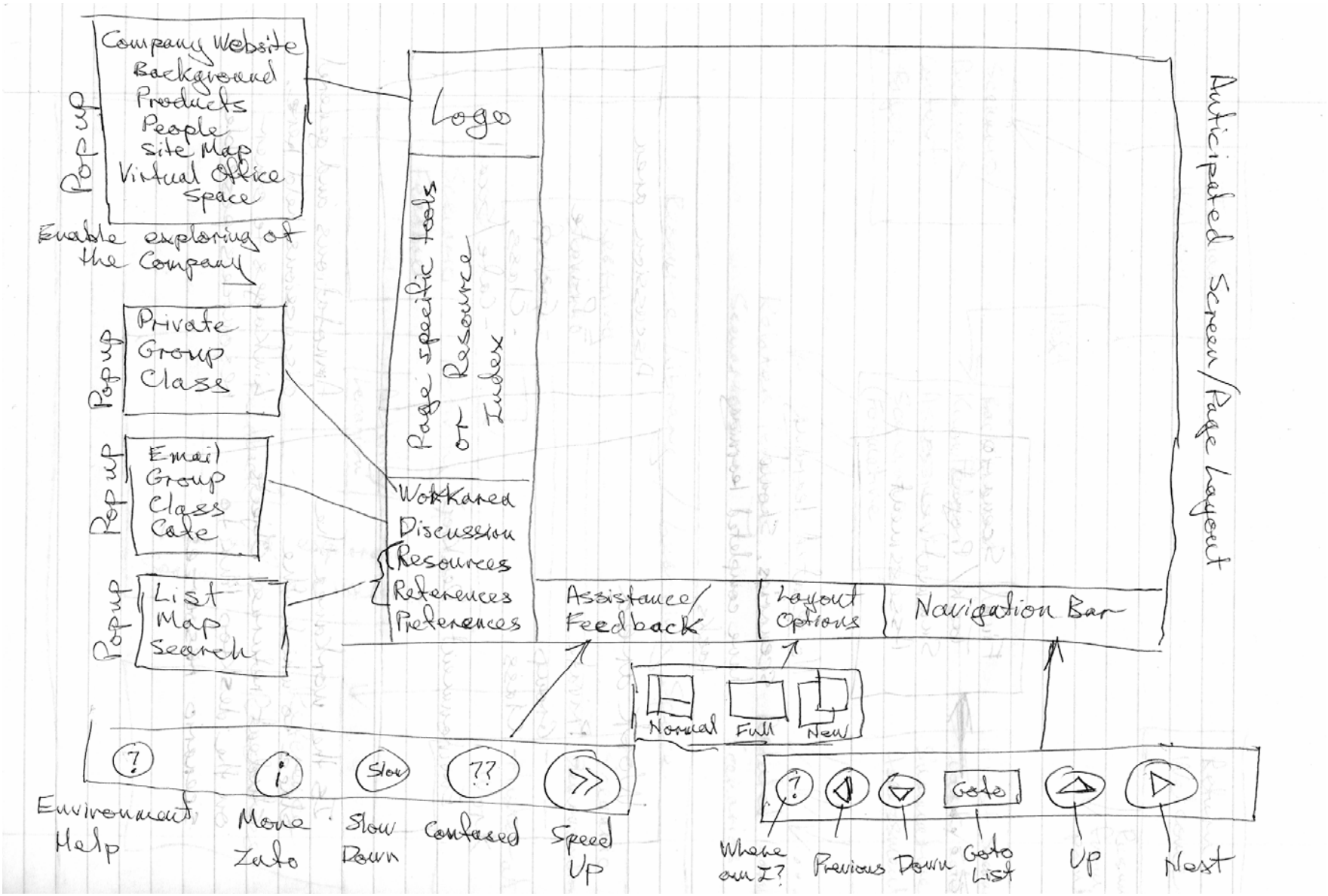


Figure 2: Anticipated Screen / Page Layout

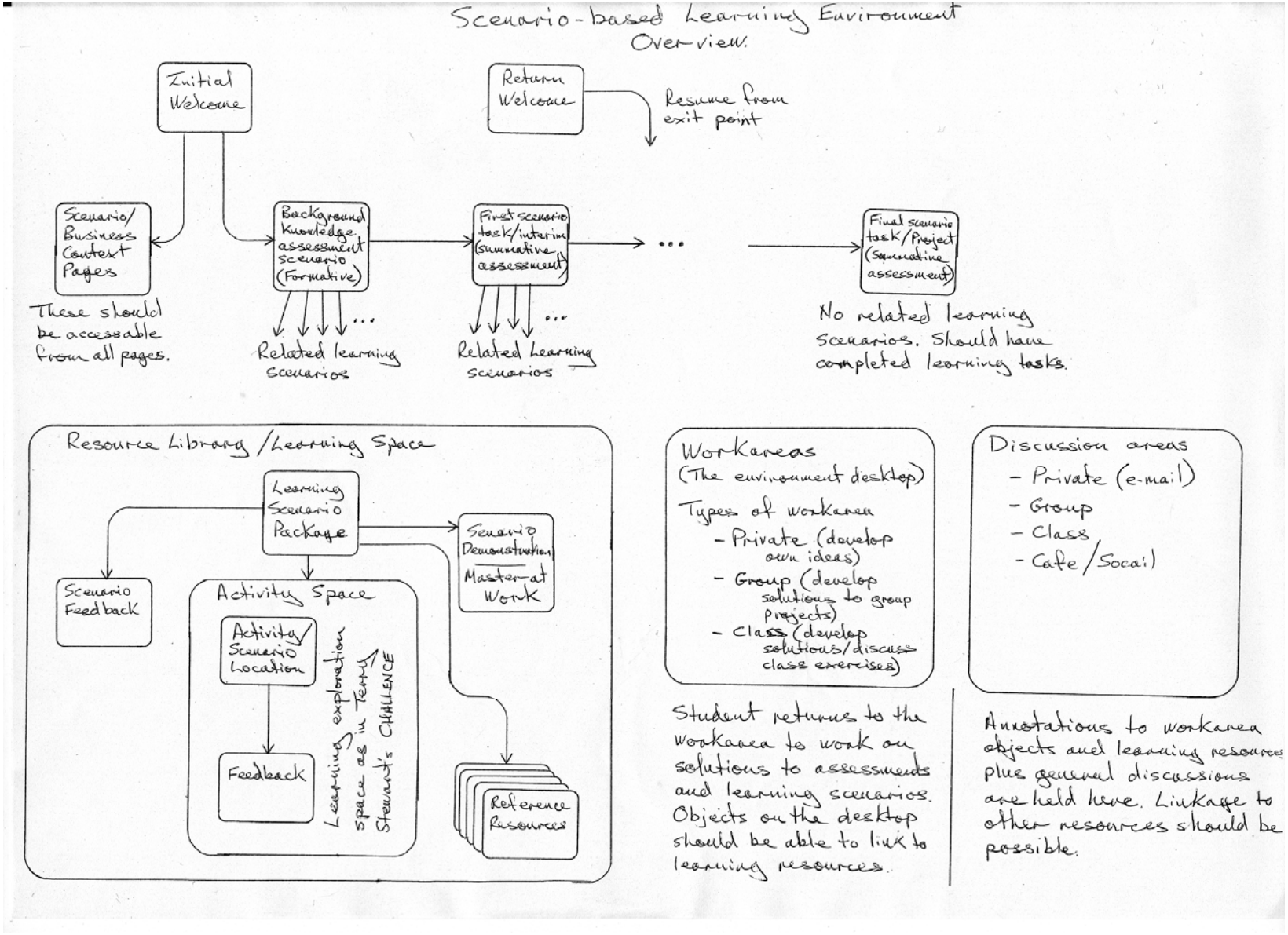


Figure 3: Scenario-based Learning Environment Overview

The primary scenario

Introduction

The presentation of the primary scenario is a key component in capturing the learner's attention and leading them into the learning environment. In "An Introductory Scenario" (page 5), I endeavoured to paint a picture using words of a possible opening scene for a scenario. In that scenario, I ended with the first task being introduced. In this scenario, I purposely described some objects that were in the offices. These objects represented possible sources of information for the learner that might be taken into later learning tasks.

Paper-based limitations

In the paper-based environment, all of these resources need to be included in the materials given to the learner. This can lead to information overload and confusion as to what should be read next. Our presentation involved providing the student with some introductory material followed by the background knowledge assessment and the assessments for the paper. The learning resources then followed the introductory material and assessments. They were sequenced in the order that it was considered most students would complete the learning.

We provided a map of the learning resources showing the dependencies that we had designed into the materials. This map also provided some choices of paths through the materials. In each assessment, we also listed the learning resources that covered the topics being assessed and each learning resource included references to knowledge learning resources.

We believed that these links would act like hypertext links to the learner and that they would be able to make choices based on prior knowledge and experience. For a distance learning paper, this type of structuring was unfamiliar to the learners.

Online option

In an online environment, these can be accessible through menu options or selection areas around the primary work area. They are potentially objects that the learner can collect and carry with them or leave to be returned to if needed. In this sense, the environment can take on the feel of an adventure game where the learning space is explored as the learner works through the tasks that are set.

Even in the paper-based environment, we sought to use an adventure game approach. However, the more obvious links, the students saw as paths they had to take rather than options or choices that they had within the investigation space.

Guidance

The scenario by presenting problems provides a focus for the direction of study. However, when presented with a problem, students may still require additional guidance based on the prior knowledge and skill levels. By endeavouring to record information on the learner's progress and the type of help that they have sought from the system, it is envisaged that guidance would be adapted to the student's needs. In the form design (see Figure 2), we have included buttons labelled slow down, confused, and speed up. The intention of this type of button is to enable the learner to provide feed back about the pace of the learning and to seek a greater level of help than what might currently be provided by their assessed profile.

Presentation

A paper-based presentation of a scenario is built by word picture possibly supported by photographs and illustrations. An online environment opens up the possibility of using a three dimensional space (a virtual world) which the learner can explore (e.g. Active Worlds and games).

A three-dimensional world or game space allows the learner to interact with the environment possibly collecting articles and references as they go. One of the advantages of these spaces is the interaction that can occur from a group of learners all interacting in the same space. As will be seen later in the discussion on workspace (see page 23), this could be used to foster the development of teamwork.

As well as the learners being part of the space, additional simulated characters or intelligent agents could be utilised to simulate the type of people that the learner would need to interact with in that environment. Looking back to the word picture scenario, the current workers may be represented by intelligent agents/simulated characters. The result would be that the learner would participate in a simulated company with its daily business functions happening.

A learning resource library

Introduction

The learning resources are what the learner turns to when they are struggling with a concept or idea that they need in order to complete an assessment or learning task. Learning resources in a paper-based or lecture-based world tend to be sequential. The vision is for a multi-dimensional learning space into which learning resources are placed. The learning resource to which the learner turns may be anywhere in the learning space and be found using the systems knowledge of the learners progress and development.

Learning space model

As I have developed learning resources, the thinking on the relationship between resources has gradually changed. In the initial designs, we focussed on the divisions in the subject area and the relationship between the subject area divisions. This lead to learning resources of varying complexity, that were difficult to estimate the length of time required for the learner to complete. Our first attempt at further division was to apply a cognitive hierarchy (Bloom et al., 1956; Facione, 1990). This could also be represented by Merrill's Component Display theory (Merrill, 1994b; Merrill, 1994a).

Our current thinking is to explore the use of a multi-dimensional learning space. One possible depiction of this space is presented in the following diagram (Figure 4). This is an over simplification of the dimensions especially as the subject area skills could be seen as multi-dimensional.

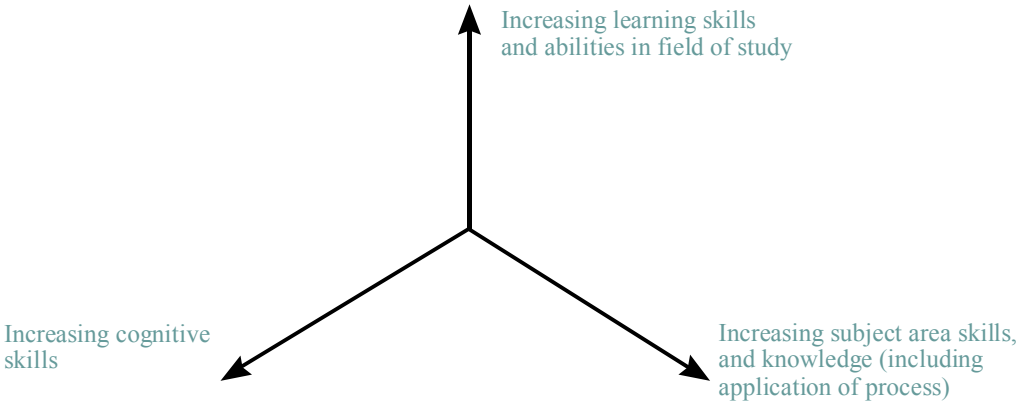


Figure 4: Learning space dimensions

The third dimension labelled increasing learning skills and abilities in the field of study could equally be labelled increasing meta-cognitive skills or increasing maturity of learning. This dimension is currently under investigation.

Not shown easily with in the dimensional space is the clustering of learning resources that might occur around subject area themes or the inter-relationships that are based on the application of elaboration theory (Reigeluth et al., 1994b; Reigeluth et al., 1994a). In the elaboration theory approach, the learner revisits the subject area content repeatedly having previous content reinforced, and having additional detail added. The structure of learning resources and the learning space could easily handle this approach.

Alternative learning space models are possible. One such model is subject area concepts, subject area process, cognitive skills, metacognitive skills, and learning maturity. The distinction between subject area concepts and subject area process is that concepts represent the facts, ideas, and techniques that are used in the process.

The thinking here comes from process frameworks such as the OPEN process framework (Firesmith et al., 2002).

Learning resource and learning space model

The learning space can be viewed as a vector space (Kurhila et al., 2002; Kurhila et al., 2001; Salton et al., 1975) The mathematical model presented in these papers position learning seeds within a learning space. The learner can then be guided to appropriate resources based on their current knowledge and skills.

This type of model helps position learning resources within a learning space. To some extent, the model presented earlier is this type of learning space with its defined dimensions. Required knowledge and skill points fall within this vector space.

However, our learning resources are not points in the learning space. They are better considered as transitions between points in the knowledge space. Vectors that represent the position within the learning space can represent the starting point (prior knowledge expectation) and end point (exit knowledge expectation) for a learning resource transition. In this context, a learning resource may be described by

LR → (SP, EP, T)

where LR represents the learning resource, SP is the start point, EP is the end point and T is the transition or learning activities required to move from the knowledge point represented by the starting point (SP) and the end point (EP). Vectors of the coordinates of the learning space are used to represent SP and EP.

What is the advantage of this type of model? If we were to examine an adventure game space, it can be represented by a goal and areas of exploration. The areas of exploration are points within the game space and may have additional characteristics attached.

In a scenario-based learning environment, we also have a learning goal (the learning outcomes) and an exploration space represented by the learning space and the learning resources placed in that learning space. The transition between learning resources represent the transitions that have been allowed for within the learning space. As a learner interacts with the scenario-based learning environment, they move through the space and the system can present the possible transitions from the learner's current positioning within the learning space.

The thinking in this area is still very tentative and further research is required to develop it to a useable model.

Supporting references

The learning environment is not intended to be self-contained. Just as a learner might seek additional learning resources from the library or electronic databases, the same would be expected from a scenario-based learning environment.

Access to some of these supporting references could be through the environment but others may involve going to a physical library or set of resources.

The power of story telling in fostering learning and as a springboard for change should not be ignored (Schank, 1990a; Schank, 1990b; Schank, 1990c; Schank, 1992; Schank et al., 1992; Denning, 2001; Harley, 2001). Such stories could be used in a scenario-based learning environment. The work of Roger Schank and his team especially in indexing of stories and in implementing case-based reasoning systems needs further investigation both as a way of structuring the learning space and as a way of providing access to a range of additional resources.

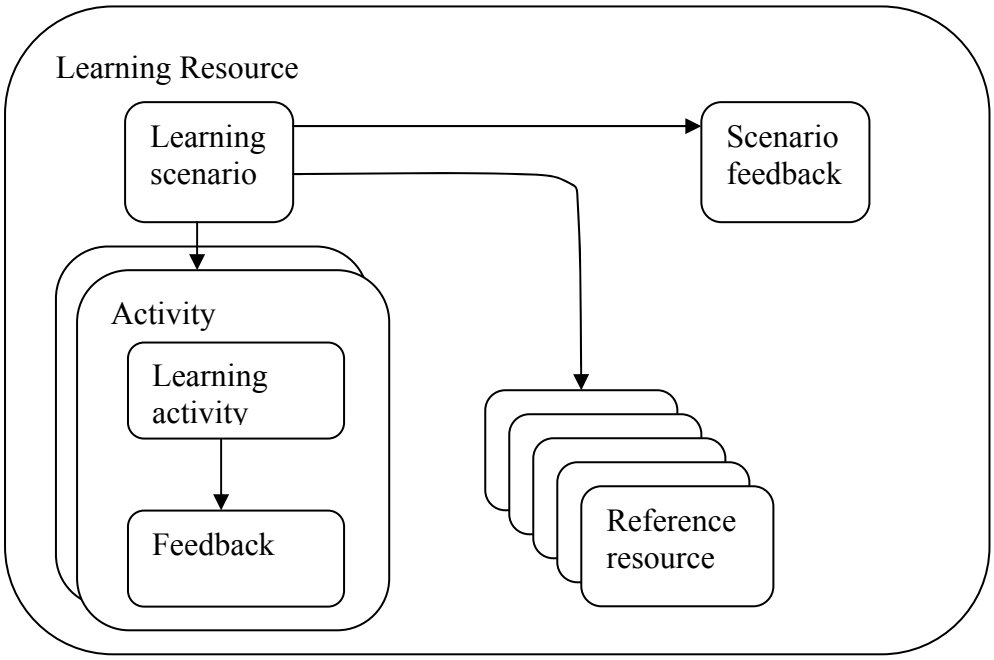
Learning Resource

Introduction

I am deliberating using the term learning resource here rather than learning object (IEEE LTSC, 1999; Bohl et al., 2002). A learning object can be viewed as any object that may be used in learning. The object does not need to provide guidance or direction on its use. A learning resource, in contrast, is focussed on guiding the learner to a particular learning outcome. It is a combination of reference material, guided instruction, and formative / self-assessment.

Structure

In the paper-based version, a learning resource comprised an opening learning scenario, a list of possible reference resources, a series of learning activities with feedback, and feedback for the opening learning resource scenario.



The opening learning scenario clearly specified a task that the learner should be able to complete if they had the knowledge taught by the learning resource and the criteria against which the learning could be assessed. The objective was that the learner could attempt the task using the criteria to evaluate their own level of knowledge. The scenario feedback provided more detail on possible solutions to further aid the learner in ensuring that they had the required knowledge.

The learning activities are designed as a sequence of guided tasks designed to develop the required knowledge base and skills. Hints and guidance were provided that would either provide direction on the steps to take or reference material to read. The feedback provided information that could be used to confirm that the learner had a valid solution.

The theory behind this structure was that each activity fostered a small element of learning and would build on the knowledge gained from previous activities. To provide the ability to self-assess, the feedback was provided. When the solution or hints of the solution are provided in the feedback, the learner would often turn to the feedback when they were in doubt rather than complete the task and then evaluate their learning. The result was that learners often didn't learn the skill or knowledge required because they simply copied the solution.

Apprenticeship models

The structure of individual learning resources can be designed around a cognitive apprenticeship model (Collins et al., 1989). In this environment, the learner is able to observe the master at work and then to mimic the master's approach to the task.

Resources prepared using an apprenticeship strategy require the ability for the learner to observe the master at work or a scenario demonstration. These scenario demonstrations should demonstrate both the required skill set and the cognitive skills utilised by the master practitioner.

The activities should be designed to draw the student into completing more and more of the task and thinking behind the task. The master should move more and more to an advisor role and decrease the amount of support that is provided to the learner.

In classroom teaching, rather than presenting a lecture, the lecturer can take on the role of the master working through to resolve a problem. In this scenario, the lecturer attempts different solutions and verbalises the thinking that causes some solutions to be rejected and others to be accepted. The lecture becomes an opportunity for the learner to observe the master's process and reasoning strategies. In areas where the lecturer believes the students should have developed the appropriate reasoning skills, the lecturer could ask the students for their input to the process. Increasingly, the students are drawn into the process and thinking strategies with the lecturer and the lecturer begins to be the facilitator or guide rather than completing the exercises.

In the envisaged environment, the learner should have the ability to replay the master at work so they can look at different aspects of the master at work. The activities should be structured to encourage the learner to take increasing responsibility for the task. The activities should force the learner to look at the scenario demonstration from different aspects. For example, the initial focus may be on the master's solution. The activities would then draw the learner to explore the reasoning or process aspects of what the master has been doing.

As the learner's confidence increases, the learning environment should gradually remove the support of the master so that they are increasingly left performing the task and the reasoning for themselves.

Learning resource creation issues

The nature of the opening learning resource scenario is the key to ensuring that the appropriate knowledge or skills has been or is being acquired. A shallow scenario may see a student assess themselves as knowing the material in the learning resource but discovering later that there were details in the activities that were not reflected in the opening scenario. At the other extreme, an overly complex scenario can leave the learner bewildered and believing that there is too much to learn in this resource. It is important in the initial planning to carefully design the learning resource scenarios so that each learning resource will be of similar complexity and the scenarios clearly define the expected learning outcomes.

Within a learning resource, the knowledge and skills should be developed at a rate that the learner feels comfortable. This may mean that initial activities have a higher level of guidance than later activities. Ideally, the level of guidance should be related to the learner's cognitive and metacognitive skill levels and be adjusted based on an assessment of these skills. In recent attempts at writing learning resources, the concepts of cognitive apprenticeship (Collins et al., 1989) have been applied.

The nature of the activities also needs to be carefully considered. An activity should present a problem that requires the underlying knowledge, skill, or technique to be applied at the appropriate cognitive skill level. Each activity should build on previously learnt knowledge, skill, or technique reinforcing the knowledge through iterative application in increasingly more complex situations. In a learning to program context, this has been achieved through progressive programming exercises (Thompson, 1992; Thompson, 2003c). The development of such exercises can be time consuming and it is tempting to move directly to more directed activities that use the knowledge, skill, or technique once. The apprenticeship model of learning (Lave et al., 1991; Wenger, 1998) encourages repeat application and participation in an environment where the knowledge, skills, and techniques are being repeatedly applied.

The nature of the activity feedback also needs to be considered. In a paper-based environment, it is not possible to provide feedback that is based on the individual student's solution to the exercise. The feedback has to be generic and highlight the key issues of the activity. I have tended toward feedback that strongly hints at key aspects of the solution rather than providing a solution. This works where the learner has a degree of confidence in their ability to self assess their own work. Where we have provided a solution, we have discovered that some students will turn to the solution and not complete the task on their own. The result is a failure to develop the cognitive and metacognitive skills that should become an implicit part of their approach to tasks in the field of knowledge (Thompson, 2003c) and would be used in the context of reflective practice (Schön, 1988; Schön, 1983) and in expert thinking (Chi et al., 1988; Soloway et al., 1988; Soloway et al., 1988).

Creativity and critical thinking

In some respects, this is a side note. However, the concepts introduced here reinforce the problems with providing solutions in the feedback.

In reading material on cognitive skills, innovation, and creativity, it has become increasing clear that these higher cognitive skills are difficult to teach. We may see a creative solution to a problem but if a student takes that creative solution and reuses it even with slight modification, it is no longer a creative solution. What was creative last year isn't creative this year. It is a copy.

Similar applies to critical thinking and development of an argument. If the student copies or adapts an example solution, have they developed the skills of critical thinking or have they simply learnt to copy another's argument?

In a programming context, we can provide material that introduces a concept (i.e. a data structure) that is to be implemented and/or example code in the language that a student is using. If the student copies the example code modifying variable names, have they learnt that concept and how to implement it? Some do but many can neither explain the concept or how the code works that implements that concept (Thompson, 2003b).

These issues are central in providing feedback or solutions to learning activities.

Alternatives

My trend has been to move toward a series of activities that are sequenced to build the skills that the learner requires in order to complete the assessment task. Although this may portray or model the cognitive skills required, it does not necessarily develop those cognitive skills or the metacognitive skills. With this in mind, I see the possibility of a range of alternative structuring techniques for learning resources.

A possible learning resource structure based on metacognitive skills development might be:

- The learning resource task would present a problem scenario in the subject area and have the student present strategies for resolving the problem and their reasoning for their chosen strategy.
- The activities would provide a number of solution strategies or suggested avenues of exploration that might lead to a solution. The number presented would depend on the student's current ability to critique and select options.
- The student selects a strategy and applies to the scenario.
- The student presents their solution and reasoning.

A variation that matches the adventure game style of scenario would be:

- The task would present the students with a problem or task and have the student present how they would assess their solution to the problem or task.
- Present solutions to the task some of which would be incorrect along with assessment strategies that imply the solutions are correct. The student has to critique the assessment criteria and improve them.

Revising the learning resources

With an increasing understanding of the nature of expertise, I am now looking at a revised approach to the relationship between learning resources. In the overall structuring of a learning experience, I am looking at

1. the thinking patterns used in the subject area domain
2. the key process concepts of the domain (Process as content (Costa et al., 1996; Costa et al., 1997; Young, 1996))
3. the cognitive skills applied within the domain
4. the metacognitive skills

A set of learning resources must support the primary learning objectives. Some of the topics of the above foci need to continue to be reinforced across learning resources. Here I am thinking of the key process concepts of the domain and the cognitive evaluation strategies.

The selection of scenarios might be based on the approach promoted in elaboration theory (Reigeluth et al., 1994a; Reigeluth et al., 1994b). This focuses on starting with an overview and introducing detail over the period of the learning. What I see here is that instead of cognitive apprenticeship being applied simply to a learning resource, some of the process, thinking, and evaluative strategies will have the cognitive learning strategy applied across learning resources.

This would mean within a learning resource, I would expect to see a structuring that had the following elements:

1. The primary scenario concept
2. A reinforcing of the context and process
   2.1. The application of the process to the concept
   2.2. Or the usage of the concept within the process
3. An evaluation of the effectiveness of the concept

4. Integration of concepts (i.e. the application of global principles to the new concept)
5. Exploration of learning strategies or ways of exploring the concept (i.e. developing self-directed learning strategies in the subject area)

Versioning

Learning resources should be versioned and a history of changes maintained. It is envisaged that resources will be updated on a regular basis. Some of these changes will be minor. Others will involve major rewrites. This history of development should be maintained so that review of any learning resources development can be accomplished.

Versioning also happens on another level. A particular offering of a learning opportunity (a paper) is based on a particular set of resources or versions of resources. Review of what learning resources where used for a particular offering should be possible.

In this context, two versioning concepts relate to learning resources (similar applies to program source code). There is the version of the learning resource (a particular source code file) and the version of the learning offering (program or system version). Both of these versions should be maintained within the system. Tools such as Subversion support these concepts through revisions, tags, and branches. These concepts should be applied to learning resource version management.

Research issues

The issues surrounding pedagogical style, learning styles, cognition, meta-cognition, and the learner's approach to learning or learning process need to be evaluated in terms of this style of learning environment. From work at The Open Polytechnic of New Zealand, it appeared that students who had a well-developed learning strategy or learning process were more able to handle the scenario-based learning approach.

A focus for future research would be in the assessment of the maturity of a student learning process in a way that software development process maturity is assessed with the Capability Maturity Model (Paulk et al., 1993) and Software Process Improvement and Capability Determination (El Emam et al., 1998). For learning processes, the cognitive skill levels may provide an initial indication of the maturity of a learner's learning process but the evaluation of the cognitive skills for ongoing learning process improvement would be accomplished through the application of metacognitive skills. How to apply this type evaluation to a scenario-based learning environment to adjust the levels of feedback and guidance would also require further research.

The workspace

Introduction

The original thinking for this environment was based around the teaching of software development papers. In this environment, we want to encourage dialogue on the design and code implementations that the students are working on. The workspace isn't simply a solution space. It is a space for being able to represent the student's current learning model and the path that they have taken to the solution.

Purpose

The workspace is more than one workspace area. It would comprise a number of workspaces each with the same capabilities.

The central workspace would be used for the teaching project. All students would have access to this workspace and the lecturer would be involved in this workspace as the coach of the development team. This workspace would contain all the objects being developed or discussed in the teaching sessions. The intention is that these objects would be developed by the class as if they where the team working on the teaching project.

Each student project group would have its own project space. The project space contains the current objects that form the status of the group project. In the case of systems development projects, this would include analysis and design documents, diagrams, analysis and design models, and the programs (code) being developed.

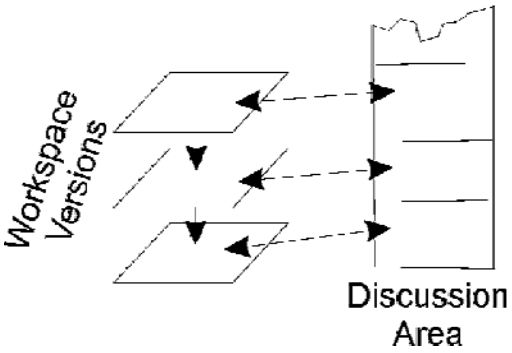
There should also be the possibility for students to have individual workspaces in which they can develop and experiment with their own thinking.

The lecturer would only participate in the group and individual student work areas when invited by the students.

A workspace shared area should exist to enable priming of the workspaces with the project specification. This specification would be common for all group project workspaces. Revisions to this shared material should also be reflected in the project workspaces. This material could not be updated by the students although they could reference it for discussion.

Version control

A key feature of the workspace is the ability to save and compare versions of the workspace for later review. Ongoing development of the project would occur in the current version until a new cut off point is reached and a new version is created. While working on a version, alternative paths of development might exist. At the point of finalising a version, these different threads would be pulled together as a current agreed status. To support discussion of the different development paths, the workspace should be able to be linked to the discussion area. The following diagram endeavours to illustrate the relationship between versions and the discussion area.



At any time, a student should be able to view any version as it was at the time that it was finalised, to compare versions, and the process used to get from one version to the next.

The ideal would be that only changed objects or the changes to objects would be held in a new version workspace. These changed objects would overlay or replace objects in the lower levels. The granularity of the objects would be important. It may be some portion of a model or document.

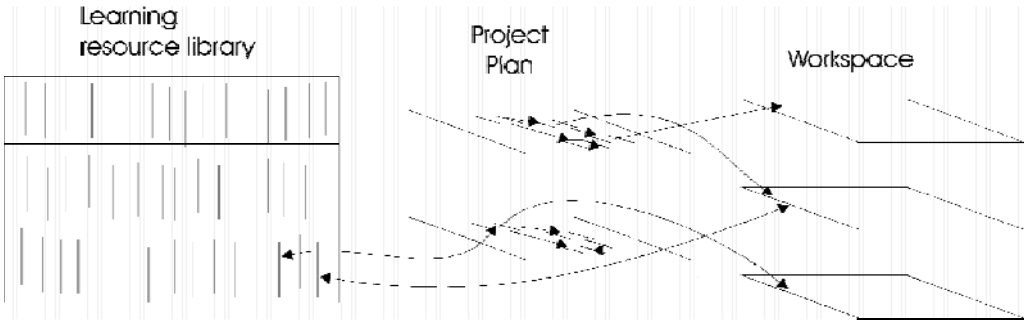
The version control mechanisms could use or be based on existing version control software such as Concurrent Version System or Subversion. Subversion is of particular interest because it supports the versioning of directories and retains differences between versions rather than full copies. Another feature is that these version control systems support concurrent update followed by merge of updates. This style of versioning is required for the workspace that could have multiple people updating them at the same time. Some issues would need to be dealt with where graphical material was being updated.

Usage

During discussion, a person may add a proposed revision to the workspace linked to a discussion item giving their reasoning. They do not create all the project documents but just an amendment. This is like a transient version of the workspace that could then be accepted or rejected by the project group. This would be accomplished by drawing together of the discussion toward a new agreed version. Various proposals for change may be under discussion at any given time.

Planning space

Either as a separate space along side the workspace or as a sub-area of the workspace, there should be a planning space. Project plans or iteration plans can be developed in this area. The objective of the planning area is to enable regular review points and revision of direction. This is illustrated below.



It should be possible to link project tasks, phases, or other planning elements to versions of the workspace. One of the issues is that a plan revision may be linked to multiple versions of the project workspace.

Planning elements should include the activity, task, and technique concepts used (see OPEN process framework (Graham et al., 1997; Henderson-Sellers et al., 2000)). The planning process should involve choices that will influence what needs to be done, what techniques should be used, and what learning might need to be completed.

The project plan therefore drives the learning and choice of learning resources. To achieve this, project activities, tasks or techniques should be able to be linked to learning resources in the learning resource library.

Cognitive and metacognitive support

Learning is more than applying skills. The development of reasoning and of skills to select appropriate learning strategies is also important. When working in the workspace, the learning should be provided with support to help them develop appropriate cognitive skills. It should also recognise the level of metacognitive assistance that a student needs in order to make appropriate learning choices.

The planning space in particular should have elements for metacognitive skill development since this is where much of the planning for learning will occur.

Discussion and annotations

Introduction

Any learning environment would be incomplete if it did not provide support for some form of discussion. However, the discussion environment should include more than the normal threaded discussion area. Annotations to workspace items and to learning resources should also be maintained in the discussion area.

Types

There are many examples of discussion tools. Some are designed to stand-alone and others are incorporated into a learning environment. This scenario-based learning environment should build on some of the features of these discussion tools.

Leuf and Cunningham (2001) have developed a web-based collaborative system for maintaining web resources and fostering discussions. These Wiki developments are of particular interest as an example of collaborative document and discussion development. These environments have been enhanced to incorporate the ability to add comments and to maintain web logs (Blogs). With these types of environments, the distinctions between resource, workspace, and discussion area can become blurred.

Annotation of learning resources is being supported by more tools. An early example of using annotations or user inserted links with web resources in a learning environment is HyperWave (Mauer, 1997). This allowed the user to select words and create links from the selected words. The approach is quite different to the page editing techniques of Wikis.

In many of these cases, the annotations are separate from the discussions. In this design, it is recommended that these annotations be maintained in the discussion area thus allowing the normal dialogue on annotations.

Structure

The discussion area should be threaded and enable threads to be closed off or drawn back to a common thread as agreement on an approach or solution is reached. The discussion entries or segments of entries should be able to be linked with objects in the project workspace. From a discussion perspective, the workspace would be like a whiteboard being used during group discussion. A person making a point will point to objects or items on the project whiteboard or amongst the other project documents. They may also add a proposed revision to that point (see Workspace Usage on page 24).

Personal journal

The discussion area should also serve as individual journal space. All the capabilities of the discussion area including linking to the workspace, to learning resources, and entries in the workspace discussions should be possible. The student should be able to draw on any resources in the learning environment when discussing issues that they see as important.

It should also be possible for the student to request comment from the lecturer in their personal journal. This would constitute a personal learning dialogue between the student and the lecturer.

Annotations

It should be possible to link to any resource in the learning environment from the discussion area. However, it should also be possible to initiate a discussion from any resource within the environment. This initiation could be in the form of raising annotations or making comments on a learning resource or something in the

workspace. In this context, an annotation or comment could be seen as initiating a new thread of discussion.

A distinction needs to be made between annotations and comments although at times, they may both serve the same purpose. A comment on a learning resource or workspace item would in general be intended for others to read and comment upon. For example, the learner may have a query about the content and be seeking clarification. A comment leads naturally to a discussion between the learner and other learners or the learning facilitator.

Annotations, in contrast, may be added by the learner to serve a secondary role as bookmarks possibly for later review. Consequently, the learner wants to be able to tag annotations in a way that will allow them to locate them later and to be able to add appropriate text to identify the reason for the annotation. The learner may also see their annotation as private or open to others for investigation.

Annotations used in this way may need to be tagged with a review by date. That is to allow the learner to be reminded to return to this annotation prior to a set date or time period. This type of time management facility is an extension of the base concept but should be possible if the appropriate architecture is selected (see Software Architectural Issues page 28).

Another aspect of an annotation is that the learner may see it as a temporary notation to be removed once the point is clarified or to be amended based on later learning. From the perspective of the environment, deletion of any resource is undesirable. However, the perspective of the user and the perspective of the system can be maintained through version control. The history of annotations for a learning environment resource should be maintained in the same way as versions of the workspace or learning resources is maintained. This concept is central to the design of Wiki systems where it is possible to review the history of all changes to a Wiki page.

Learning Facilitator Annotations and Comments

The learning facilitator may also wish to add annotations or comments to learning resources. These annotations or comments may be indicating areas that need updating in a learning resource or potential problem areas that learners are having with resources. These annotations should behave in the same way as learner bookmarks. They should allow the learning facilitator or resource developer to tag the resource and to later locate those tags to ensure that the appropriate revisions are accomplished. The resource developer may want to tag the annotation with additional information to indicate how a particular update was dealt with and the date and time on which that occurred.

These capabilities for the facilitator or developer may be accomplished through the facilities required for the learner. However, they may also require some additional management facilities not required by the learner.

Annotation and versioning

Discussion forums relate to specific learning offerings. Annotations or comments linked to workspace resources belong to that version of the workspace resource. In a similar way an annotation or comment linked to a learning resource belong to that version of a learning resource.

A key element that needs further exploration is how to maintain these beyond the limitations of a learning offering. This will involve identifying those annotations or comments that are specific to a learning offering and those that relate to the learning resource and its ongoing maintenance and development.

Software Architectural Issues

Introduction

The features required for a learning environment are not static. As knowledge grows of how to provide learning facilitation features in online learning environments, the modules included will change, be added to, and some removed. The software architecture of the environment should be flexible to enable this ongoing changing environment.

Annotations, discussion forums, learning resources all sound like different software constructs but all utilise the same document concepts.

Developing the software for the scenario-based learning environment could present a number of challenges to those involved in software engineering, semantic representation, and other research fields.

Architectural issues

The following is a list of architectural issues based relevant to these learning environments (Alpert et al., 1999; Kinshuk et al., 1999).

1. The architecture needs to work both for a web environment and locally. The client server architecture and the division of responsibilities are key to the design of the system. The client intelligence will have to vary depending on the functionality. For example, the tools for working with model diagrams may require the drawing tools and model validation to be in the client simply to ensure good performance. However, there needs to be a server component to ensure that the shared model is notified of changes.
2. The concept of a student model. This is something that is in a number of proposals. This will need to record knowledge of student learning and progress with the scenario.
3. An extensible architecture (see below).
4. The IEEE learning environment model (Farance et al., 1999) concepts also need to be integrated into the architecture. This includes the idea of intelligent coaches.
5. The integration of learning objects (IEEE LTSC, 1999; Bohl et al., 2002).

Extensibility

A key consideration in the design of the software architecture is the need for extensibility. Many papers discuss the architecture of adaptive learning systems. The diagram here is an adaptation of a diagram presented in the postgraduate paper run by Associate Professor Kinshuk.

Extensible architectures are not unique to learning environments. Many software development environments and productivity tools support the concept of add-ins. Many of these allow the add-in to work with the current workspace but not for the add-ins to work together unless they have been written to do so.

The Eclipse Open Source Java development environment (Wong et al., 2003; Mueller et al., 2003; Erickson et al., 2001; Object Technology International Inc, 2001; Gallardo et al., 2003) has been designed with extensibility as a core requirement. With the Eclipse environment, each component uses some form of XML description so that other components can enquire and interface with it.

This extensibility has to be incorporated into both the client and server components of the learning environment.

Possible Architecture

Part of the objective of this diagram (Figure 5) is to show the range of tools that could be included in a scenario-based learning environment. Underlying the thinking for this diagram is the extensible architecture concept and the publishing of interfaces to modules.

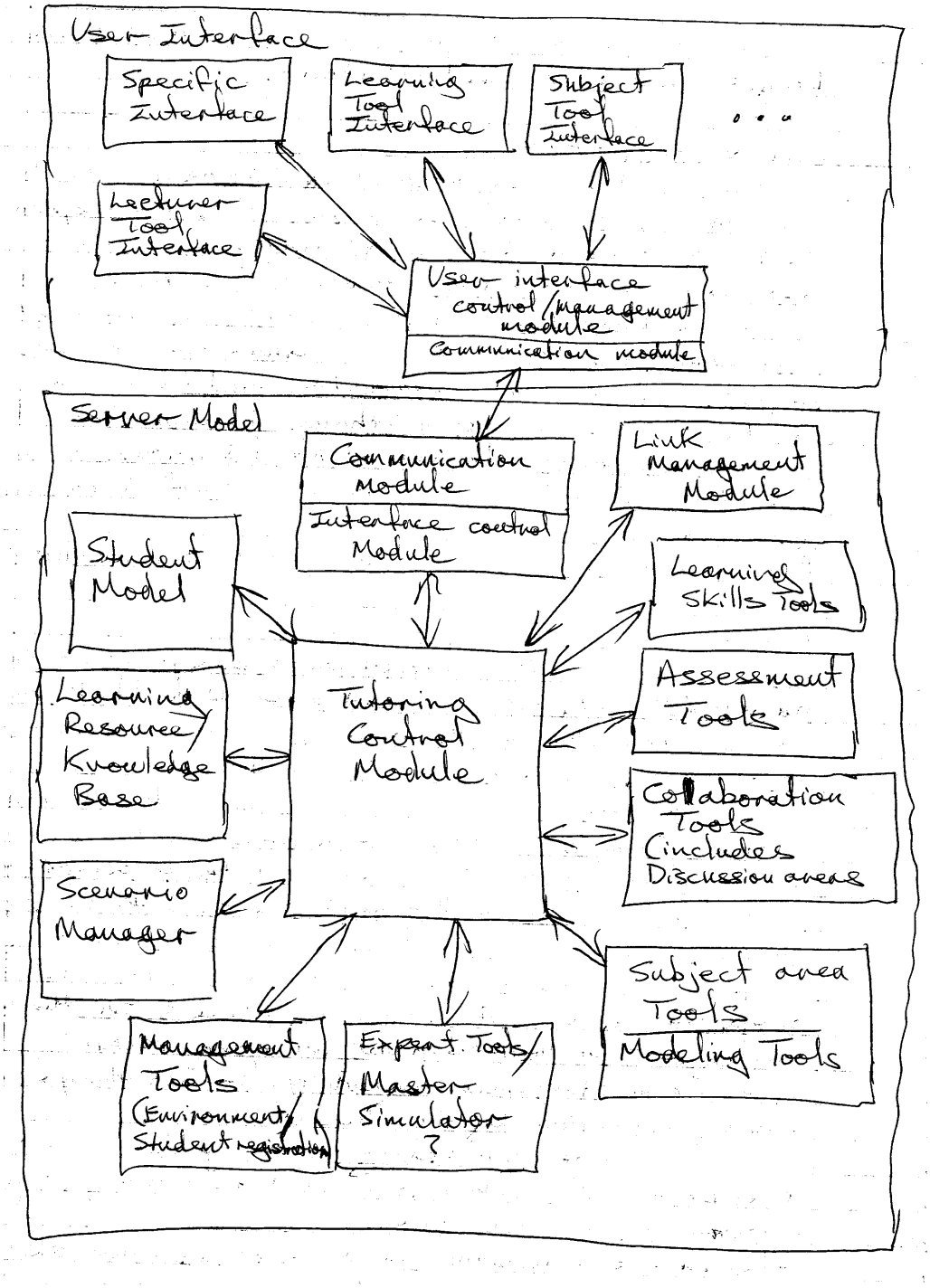


Figure 5: Possible Architecture

Some tools will have specific interface components or modules. This is reflected in there being an interface module and a server module for subject area tools. The linkage between these modules is probably static. There may also be static links between modules both in the user interface and server models. Ideally, most

interaction linkages should be dynamic. Modules should publish their interfaces so that modules can interact freely. One of these interfaces should be the publishing of hyperlink targets. These targets should be portable into other modules so they can create bi-directional links between components in the system.

Extensibility should be implemented through these targets and published interfaces.

Environment features

Some of the tools and modules are focussed on specific aspects of the learning environment and its management. These include Lecturer interfaces, management tools, subject area tools, collaboration tools, assessment tools, etc.

It is envisaged that the system will utilise a model-view-controller pattern or similar architecture. However, to enable the system to operate in a web environment, it is envisaged that a communication and interface module would be part of the core of the controller capabilities.

The user interface control and management module on the client side would provide the primary features for managing the learner workspace. This module would be closely integrated with a communication module that interfaces to the equivalent module on the server side. An interface control module on the server side would manage the workspace model for the server components and interface with the tutoring control module.

The Eclipse software development environment utilises the concept of a workspace as the share interface to the user. Tools integrated into the Eclipse environment present windows within the workspace or work with existing windows such as the code window or a model window. A similar concept may apply to an extensible learning environment.

Although all other tools are seen to interface with the tutoring control module, it is envisaged that some of these tools would provide capabilities that can be utilised by other modules. Examples of this would be the link management module and the expert tools, and the student module. The tutoring control module provides the means for this flexible communication between modules.

Warning

This model is still in the preliminary development phase. Although I believe that platforms such as Eclipse will provide clues to its implementation, there is still a lot of investigation and experimentation to be performed to verify the validity of this approach and to ensure that it is feasible.

Research perspectives

Overview

Introduction

Developing a scenario-based learning environment that is as comprehensive as I have attempted to describe here is a major undertaking. It is therefore important to recognise that a project of this type can become an umbrella project that draws together a number of research threads. Some of these research threads have already been highlighted.

This environment could also provide a much richer environment in which to prove some research areas and bring them to practical use.

In this section, I will highlight some of the potential research offshoots that I see coming from this project.

Learning issues

A lot of research is already happening related to the understanding of learning and its translation into adaptive learning systems. This research includes work on cognitive apprenticeship, exploration space control, meta-cognition, and learning process evaluation.

Part of the key for this research is to be able to present to the learner material that matches their current learning needs and helps them expand their skills with respect to the subject matter and to their approach to learning.

Technical issues

Although I have drafted an architecture based on the work of others, there is still extensive work required to develop an appropriate architecture, the core intelligent tutoring module, intelligent agents, and 3D graphics tools.

In my field of teaching, software development, most tools are still based on the local computer platform. A shared source control repository may be used but not a shared development workspace. The environment envisaged here would seek to utilise a shared workspace for the development of models, testing strategies, and code. Investigation of shared workspace environments for software development is occurring but still in the early stages of development.

Systems development processes and strategies

Although this project could utilise existing software development processes and strategies, it is envisaged that there would be scope to explore new processes and strategies.

With software development being a key part of developing this environment, we would like tools that would facilitate this development and ensure quality of the finished product. Two areas of current interest because of my teaching responsibilities are test-driven development (TDD) and model-driven development or architectures (MDA).

I am also interested in pursuing the thought patterns that make it easier for novices to learn to use object-oriented techniques and patterns. A project such as this with its continued development and changing requirements would present an ideal environment for exploring some of these thinking patterns and their impact on the development project.

Conclusion

I have endeavoured to include as much as possible of my current thinking and thoughts into this report. Many still require extensive work before they can become reality in any meaningful system.

My intent in writing this document is to stimulate others to pick up some of the ideas so that we may progress the thinking. I am a person who explores ideas and approaches from a practical application perspective. Research for me may come from a theoretical base but it needs to have a practical application. A project of this nature can move research from a theoretical experiment into a practical tool to support ongoing learning.

I would seek that others might also catch the challenge a seek to contribute to the project and the possibility of delivering a learning environment that provides capabilities beyond the current breed of present, discuss, and assess tools on the market.

References

Introduction

The following references are those that I have cited in the body of this report. It is not an attempt to include all the relevant references that I have located to date. Even then, it would not include everything that was relevant. However, it is a starting point for anyone who would seek to follow up on some of the thinking in this report.

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