INKA: USING FLOW TO ENHANCE THE MOBILE LEARNING EXPERIENCE

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ABSTRACT

Many teaching strategies used today are those based on a reward and punishment framework. This has many disadvantages, such as stifling creativity and inhibiting the growth of independent thinking. Csikszentmihalyi’s model of flow offers an alternative approach: instead of doing tasks solely for extrinsic reasons such as to acquire course marks, the flow model maintains that if certain conditions hold, the experience of doing a task is likely to be enjoyable. There are several conditions required for a flow experience to occur. The most important of these is to match the difficulty of a task with the current skills of the student. The problem is how can we create the conditions of flow? We have developed Inka, a mobile teaching assistant tool that helps plan learning sessions for individual students, designed to produce the conditions necessary for flow. When one or more of the conditions of flow are absent, the tool can suggest modifications to the session so that the conditions may once again be present. We are currently evaluating Inka with students from a first year undergraduate Introduction to Java Programming course and the results so far have been promising.

KEYWORDS

mobile learning tool, flow, context-aware systems

1. INTRODUCTION

Many teaching strategies used today are based on the ideas of behaviourism: desired behaviours are rewarded in the hope that they will be repeated, and undesired behaviours are punished in the hope that they will not [Shield]. While these strategies can yield impressive results, they have serious long term disadvantages. They can stifle creativity and inhibit the growth of independent thinking [Steels]. Moreover, motivating students with the lure of a reward or the threat of a punishment can condition them to value completing tasks as quickly as possible with little regard for the experience of doing the task.

In the field of psychology, Csikszentmihalyi developed a model of optimal experience which subsequently became known as flow [Csikszentmihalyi, 1990]. The flow model suggests another approach to motivating students: they are motivated not by a reward which will be received upon completion of a task, but by the experience of doing the task.

Flow is described in [Csikszentmihalyi, 1990] as “the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it”. Csikszentmihalyi found that in order to transform an ordinary experience into a flow experience, the following conditions are necessary. First, we must engage in a challenging task that requires skills; we must stand a chance of completing the task so our skills must match the challenges of the task. Second, the task must have clear goals. Third, the task must provide immediate feedback. Fourth, we must be able to concentrate on the task at hand. Finally, we must have a sense of control over our actions.

Csikszentmihalyi noted that while flow may occur ‘occasionally’ by chance, it is much more likely to occur when the necessary conditions are explicitly created, for example by doing a structured activity. The problem is: how can we create the conditions of flow? The contribution of this paper is to suggest an answer to this question.

There is related work on flow and learning such as [Kondrat] and [Pearce]. In both experiments, users engage in a one hour learning program and then variables related to flow are measured. Neither, however, is concerned with creating the conditions of flow, which is our chief aim.

There is also related work in the field of adaptive systems. Adaptive systems are those that adapt themselves to their user. Many interesting examples of adaptive systems for learning have been reported (for example [Beale and Lonsdale], the KBS Hyperbook [Henze and Nejdl], and ELM-ART [Weber and Brusilovsky]). These systems create a student model that consists of such elements as student knowledge, student goals, learning styles and device. Using the student model these systems adapt content from a content repository for the particular student. From the point of view of creating the conditions of flow, they are limited in significant ways. The notion of content (such as a 'text unit' from the KBS Hyperbook) does not conform to the requirement that we have a task that has both a clear goal and a means of providing feedback (that is information about how well a user is doing with a task). Although some of the systems consider difficulty, the notion of perceived difficulty is absent. Furthermore, feedback is limited, for example sensors cannot be used to determine it.

2. THE FLOW MODEL

Csikszentmihalyi developed a model of optimal experience or flow as it subsequently became known. He studied many different activities such as rock climbing, chess, dancing and meditation, and found that when a person's experience is most positive, certain elements are present, and these elements are the same regardless of the activity. The elements are: the person is engaged in a task that he stands a chance of completing; the task has clear goals and gives him immediate feedback; focussed concentration on the task; the merging of action and awareness; loss of self consciousness, and transformation of time [Csikszentmihalyi, 1990]. In this section, we describe the conditions of flow and how flow is of value to learning.

2.1 The Conditions of Flow

In this section, we describe the conditions that are necessary to transform an ordinary experience into a flow experience.

2.1.1 Balancing skills with challenges

Csikszentmihalyi concluded that the most important condition necessary for flow to occur is that we must engage in a challenging task and we must have the skills required to complete the task. If our skills are insufficient for the task we become anxious, while if our skills far exceed those required by the task we become bored. Moreover, Csikszentmihalyi's research showed that it is not our actual level of skill or the actual level of the challenge that matter, but our perception of them. The task must be meaningful to us, that is, it must be important in relation to our overall goals.

2.1.2 Clear goals and feedback

When an individual is engaged in a task, the goal of the task must be clear to him and he must frequently obtain feedback (information that lets him know how well he is doing). If the goal is not clear he cannot tell for sure if he is getting closer to the goal.

2.1.3 Sense of control and concentration

To have a sense of control, an individual must feel confident that he can influence an outcome with his actions and then actually influence it. Concentration is crucial to experiencing flow; an inability to concentrate because of an attention disorder or a distracting environment means it will be virtually impossible to experience flow.

2.2 The Value of Flow to Learning

People are often motivated to learn by extrinsic reasons such as passing an end of year exam or receiving course marks for successfully completing an assignment. However, if a person is motivated by extrinsic reasons alone, it is likely she will quickly forget what she learned once she receives her reward. The flow model contends that if the conditions of flow are present, the task is likely to be enjoyable. So, the primary motivation is intrinsic: a person does a task because it is enjoyable, and having tasted this enjoyment, she seeks it out again. Csikszentmihalyi's studies have shown that unless learning is enjoyable it will be avoided as soon as it is no longer necessary [Csikszentmihalyi et al, 1997].

3. CREATING AND MEASURING THE CONDITIONS OF FLOW

Before we can consider the problem of how to create the conditions of flow, we need to be able to detect their presence to evaluate how successful we have been at creating them. Also, Csikszentmihalyi noted that the presence of the conditions of flow makes flow likely but does not guarantee it [Csikszentmihalyi, 1990]. For this reason, we define the success of our system not by measuring if flow occurred, but instead by measuring if the conditions of flow have been created. In this section we consider first the problem of detecting the conditions and then describe our approach to creating each of them.

3.1 Measuring the Conditions of Flow

Researchers of flow in computer-mediated environments have measured quantities corresponding to both the conditions of flow and the elements that characterise the experience in a number of different ways. They have used surveys (for example [Ghani]), but as Finnernan noted, surveys are unreliable because they require the subject to recall details of experiences that happened some time ago and so the accuracy of the details is questionable [Finnernan]. Interviews have also been used (for example [Pilke]), but these have the same problem as surveys. Csikszentmihalyi developed the Experience Sampling Method (ESM) to measure flow. The ESM involves giving subjects a beeper that goes off at random intervals during the day, whereupon they fill out a form in a booklet. One study adapted the ESM to measure flow in Web browsing [Chen & Nilan]. In this study, the subjects browsed the Web and a pop up form appeared every five to seven minutes which they completed. The ESM has the advantage that the information is acquired while the subject is in the experience and so it is fresh in their minds.

Our solution is similar to the ESM and shares this advantage. It involves creating snapshots of the student's context (that is "any information that can be used to characterise the situation of an entity" [Dey]) whenever the student notices one or more of the conditions of flow have changed. The snapshot consists of the state of the context object when the snapshot is taken. The student can create a context snapshot by clicking the camera icon (shown in Figure 1) and then filling in the form (show in Figure 2). This method maintains the advantage of the ESM: that the student is in the experience and so the information we seek is fresh in her mind.

Figure 1: Student screen while working on a task; clicking camera icon creates context snapshot.

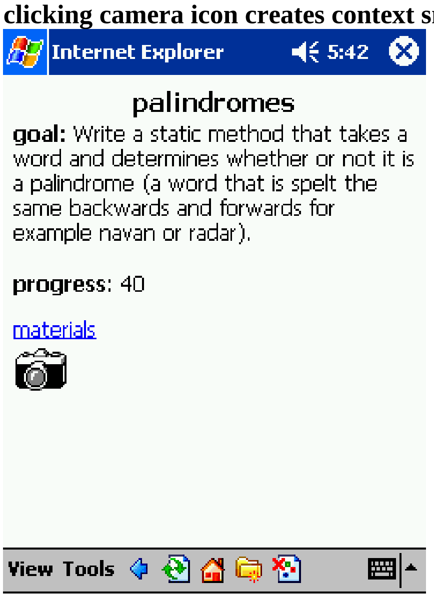
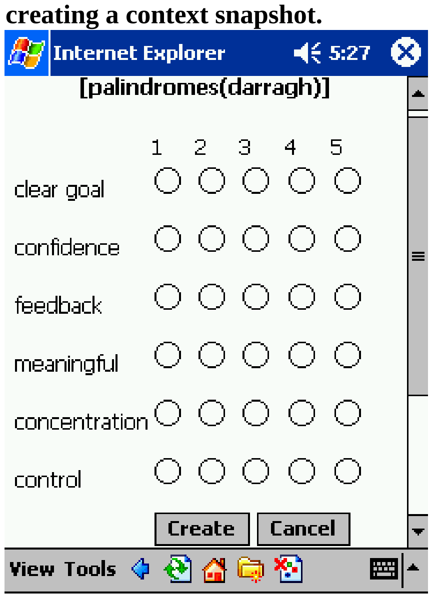


Figure 2: Student screen: creating a context snapshot.



3.2 Creating the Conditions of Flow

Our solution for creating the conditions of flow involves modelling the skills of the domain under consideration and modelling the student's context. In our solution, the student's context includes his current skills and whether or not the conditions of flow are present at that moment. This context is used to select suitable tasks from a large repository of tasks that will result in the creation of the conditions of flow.

We model the skills of the domain as a hierarchy of requirements. In order to obtain a requirement, a student has to successfully complete some test tasks associated with the requirement. Each requirement is associated with a set of tasks that will help a student obtain the requirement. These tasks are ordered by difficulty by a domain expert. For each of these ordered sets of tasks, the domain expert marks one task as the default starting task. The number of tasks from a set that a student will do before he obtains the requirement will depend on how successful he is with the tasks he is given: if the tasks are too difficult, he must first complete easier tasks from the set.

3.2.1 Balancing skills with challenges

The skill requirements can have other requirements as prerequisites so at any point in time, there is a subset of the requirements the student can be offered tasks from. A student is offered the default starting task from one of the requirements. This task can be made easier by providing him with some of the materials (hints, examples, etc) associated with the task. If the task remains too difficult (according to the perception of the student), a task lower down in the set of tasks will be suggested.

3.2.2 Clear goals and feedback

The goal of the task must be clear to the student. If it is not it must be clarified by use of examples, explaining definitions, etc. Alternatively, the goal must be altered until it is clear. As Csikszentmihalyi noted, it doesn't matter what the feedback is as long as it relates logically to the goal. The type of feedback may be different depending on the goal.

3.2.3 Sense of Control and Concentration

Since sense of control involves the individual feeling confident that he can influence an outcome, we can encourage this condition by choosing a task with the right level of difficulty. We can aid concentration by removing distractions from the environment, leaving the individual free to focus completely on the task at hand.

4. CASE STUDY: INKA

We have developed Inka, a mobile teaching assistant tool that creates the conditions of flow. The mobile nature of the tool is paramount; indeed, without mobile technology, a tool such as this would be quite infeasible. Collecting the crucial data for creating the conditions of flow must be done in the moment, having to journey to and from a computer would make this impossible.

The first decision we needed to make was what domain to build the tool for. The only requirement we needed to satisfy was that the domain supplied a set of challenging tasks that require skills. We settled on the domain of Java programming because of our familiarity with it; this was an important consideration since we had to develop the set of tasks for it, and specify the set of required skills. We chose to design the tool to be used in the Introduction to Java Programming course taught to first year undergraduates.

4.1 Current scenario

The Introduction to Java programming course involves two one hour lectures, a two hour tutorial and a one hour lab each week for 24 weeks. The class is divided into small groups of around 14 students, and a teaching assistant is assigned to each. In the tutorials and labs, a problem is set which the students must solve before the end of class. In the tutorials, the problem appears on a big screen in the classroom and the students write their solutions on paper, while in the labs the problem is viewed from a browser. The students can seek assistance from their teaching assistant who walks around the classroom. As the year progresses, the problems become more difficult. While some students manage to complete them with minimal help from their teaching assistant, many do not, even with considerable assistance from the teaching assistant. This is because the underlying assumption is that all the students have acquired in the previous classes the set of skills which are required for the problem at hand. In fact, many have not acquired all the skills so the challenges posed by the problem exceed their skills resulting in anxiety in the students. This anxiety is exacerbated by the time limit (the problem must be completed before the end of class). Moreover, motivation comes from the fact that failure to complete the problem in the class will result in a loss of course marks. The result for many is a frenetic race where their chief concern is completing the task, resulting in the student learning little and having an unenjoyable learning experience.

4.2 Scenario with Inka

Inka is a teaching assistant application that runs on a PDA which communicates wirelessly with a server. It can be used in the labs and tutorials of the programming course. In the tutorials, each teaching assistant and each student is supplied with a PDA, but in the labs the students have desktop computers so only the teaching assistants have a PDA. At the start of the class, the teaching assistant goes over to each of his students and with the aid of Inka (which suggests suitable tasks), makes a session plan consisting of a set of tasks for that student for the duration of the class (see Figure 3), and sets him to work on the first task (see Figure 1). The student creates a context snapshot straightaway (shown in Figure 2) and then each time he becomes aware that his one or more of the conditions of flow has become absent, he creates another snapshot. These snapshots pop up on the teaching assistant's PDA, marked with a white circle if the conditions of flow are present and a black circle if they are not (see Figure 4). If the conditions are not present, the teaching assistant goes over to the student at his earliest convenience to rectify the matter. There are two main ways of doing this. The first is to provide feedback and the second is to make the task easier or more difficult either by releasing a piece of material to the student or by changing the student's current task.

To provide feedback, we observe that the task of writing a program can be broken into stages. This allows us to provide feedback in the form of an estimated percentage of the task complete. The teaching assistant can determine if the student has completed a stage, usually by asking the student to talk him through the program and then asking him questions that lead the student to discover flaws in the program. The teaching assistant then creates a context snapshot on his PDA which causes the student's progress to be updated and to appear on the student's PDA (on the screen shown in Figure 1).

This process of changing the student's session plan in response to the changing context continues until the end of the session. During this time, the teaching assistant can make context snapshots in order to update the progress of the student or to make observations. Since it's possible for each student to be working on a different task, the time limit problem of the current scenario is no longer an issue – in the next class the task can be taken up where the student left off.

4.3 Pedagogical Principles

As noted by Patten et al, it is necessary that technology used in a learning environment is based on sound pedagogical principles [Patten et al]. Inka is based on constructionism, which asserts that people learn especially well when they engage in constructing personally meaningful artefacts. Student's knowledge structures are altered by constructing the artefacts (in this case computer programmes) and also when the artefact is "shown, discussed, examined, probed, and admired" [Papert].

Both constructionism and the flow model require that the task the student engages in is personally meaningful. In order to do this, the student must possess the necessary "set". This "set" metaphor is Papert's: just as a Lego artefact can be built from Lego blocks so too can a Java program be built with an appropriate set. If a student doesn't possess the complete set, he can acquire it by completing a number of tasks. However, these tasks also become meaningful because they bring the student closer to completing the task he initially conceived of as being meaningful, as Csikszentmihalyi suggests in [Csikszentmihalyi, 1990].

Figure 3: Teaching assistant screen: viewing a session plan.

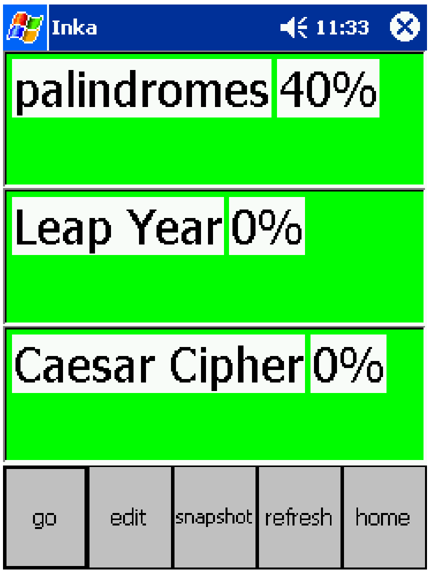
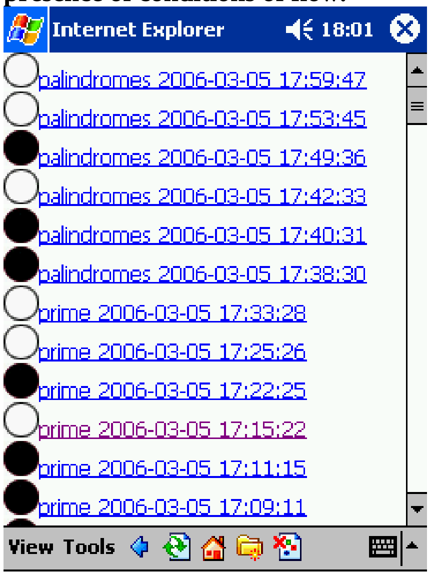


Figure 4: Teaching assistant screen: most recent context snapshots; white circle to left indicates presence of conditions of flow.



4.4 Measuring the Conditions of Flow

When a student notices that one or more of the conditions of flow have changed, she creates a context snapshot (see Figure 2). To measure if the goal is clear to the student, we ask 'how clear is the goal?' with possible answers ranging from 1 ('very unclear') to 5 ('very clear'). To measure if the feedback the student is receiving is sufficient, we ask 'do you know how well you are doing right now?' with possible answers ranging from 1 ('not at all') to 5 ('I know exactly how well I'm doing'). Similarly, concentration may be measured by asking 'how well are you concentrating?' with possible answers ranging from 1 ('not at all well') to 5 ('very well'). In order to measure sense of control we ask 'Do you feel in control?' and the student can choose from 1 ('not at all') to 5 ('very much').

To measure if the challenges of the activity match the skills of the student is not as straightforward. The ESM asked subjects to rate the challenge of the activity between 0 and 9 and to do the same for skills. In early trials of Inka, we found that students would take some time to determine these numbers and the results meant little to them. Chen et al reported similar problems [Chen et al, 1999]. The condition we wish to measure is that the challenges of the task are matched by the skills of the student, so instead of asking for the challenges and skills to be rated separately, we can ask for them to be rated together by asking the student 'how confident are you that you can do this task?' with possible answers ranging from 1 ('definitely won't succeed') to 5 ('definitely will succeed').

A rating of 2 or less in any of the context variables ('clear goal', 'feedback', 'sense of control' or 'confidence level') means that is that one or more of the conditions of flow are absent.

4.5 Evaluation

We are currently evaluating Inka with a sample of six of the first year undergraduate students taking the Introduction to Java Programming course.

4.5.1 Aims

The purposes of the evaluation are: firstly, to measure how successfully the system produced the conditions of flow during a session; secondly, on the occasions when the conditions of flow weren't created, to determine the primary reasons why they were not; and finally, to discover if the students find the system beneficial.

4.5.2 Method

The evaluation consists of taking students individually for an hour long session using Inka, followed by a short interview. The session is as described above in the section on the scenario with Inka. During the sessions, we assume that each time a student becomes aware that his context has changed, he makes a context snapshot reflecting this at once.

By examining the collection of context snapshots amassed from the sessions so far, we can estimate how much of the session the students have spent with one or more of the conditions of flow absent. We do this by calculating the duration of time that elapses between the occurrence of a black snapshot (one or more of the conditions of flow absent) and the next occurrence of a white snapshot (conditions of flow present) and summing these times for the session.

The interview questions are based on observations made in the teaching assistant's context snapshots.

4.5.3 Results

In the sessions so far, the average amount of the session spent with one or more of the conditions of flow absent is 19%. The actual figure is lower that this as the given figure includes not just the time spent with the conditions of flow absent but also the time the teaching assistant spends with the student discussing his program and providing feedback - the students do not make snapshots while the teaching assistant is present. Another factor is that occasionally students didn't make a snapshot once the teaching assistant left them, resulting in two or more black snapshots in a row, when there ought to have been a white snapshot in between them. This can lead to errors in the results.

When one or more of the conditions of flow were absent, it was largely for one or both of the following reasons. Firstly, the student no longer believed he stood a chance of completing the task causing his confidence level to drop and secondly, the student lost his sense of how well he was doing with the task and so his feedback level dropped. The total figures from the sessions so far are confidence level (72%), feedback (78%), unclear goal (17%) and a task that wasn't meaningful to the student has not yet occurred.

In the interviews, the students were positive about the system. They identified with the problem of the anxiety arising from providing the same problem to each student despite the mix of skill levels. They did not find making context snapshots inconvenient (as one student put it "it only takes a few seconds"). Another student mentioned that he liked the idea of making context snapshots because he "find[s] it difficult to put up [his] hand and ask for help during class".

5. DISCUSSION

Our concerns that the students would find making context snapshots bothersome were dismissed by their indications in the interview. However, the students occasionally forgot to make a snapshot (for example after the teaching assistant left). One student admitted that he only made snapshots when he wanted help. One way to encourage more snapshots being made would be to model the ESM more closely and sound a beeper randomly on average once in 5 minutes that would signal the student to make a snapshot. We are not keen on this since that would distract the student taking away from the concentration necessary for flow. A less distracting approach is to model as part of the context what student (if any) the teaching assistant is currently with, and when the teaching assistant departs, the student, should he forget to make a context snapshot, is signalled to do so.

We note that making a context snapshot when a student notices one or more of the conditions of flow has become absent could be distracting and so undermine the concentration necessary for flow. However, this need not be the case, since the student controls that distraction, unlike an alarm that sounds randomly. It is possible, with practise, to go from attending to the task at hand to creating a context snapshot and back to attending to the task at hand without a break in concentration.

In order to get a good match between the challenges of the task and the skills of the student most of the time, the task repository needs to be extensive. It can happen that there simply isn't a suitable task in the repository. An advantage of having a human teaching assistant in this situation is, as happened a few times during the sessions, it can spark off an idea for a new task; the teaching assistant can sketch a new task or else write down the specification for a new task which he can write later. In the session, he can select another task for the student to do from the suggested tasks.

6. CONCLUSION

We have developed Inka, a mobile teaching assistant tool that helps plan learning sessions for individual students, designed to produce the conditions necessary for flow. The main advantage of Inka is that using it, students are likely to have an enjoyable experience, whereas in the current scenario the students' experience is not a consideration. The main limitation of Inka is that in order to get a good match between the challenges of the task and the skills of the student most of the time, the task repository needs to be vast, and the cost of developing this is considerable.

The results of our evaluation so far have been promising. In trials so far, the average amount of the session spent with one or more of the conditions of flow absent is 19%. We plan to introduce Inka into the live classroom environment next term where it will initially be used by a small test group.

We used the domain of Java programming but the tool could be used in any domain that has challenges that require skills. In particular, it could be especially useful in activities where certain feedback cannot be calculated by a human, but where a sensor can measure a quantity and produce output that may be translated into feedback that is suitable for a human.

REFERENCES

Beale, R. and Lonsdale, P., 2004, *Mobile Context Aware Systems: the intelligence to support tasks and effectively utilise resources*, Mobile Human-Computer Interaction – MobileHCI 2004: 6th International Symposium, Glasgow, UK, Proceedings pp. 240-251.

Chen, H. et al, 1999, *Optimal Experiences of Web Activities*, Computers in Human Behavior, Vol. 15, No. 5 pp. 585-608.

Chen, H., and Nilan, M.S., *An Exploration of Web Users' Internal Experiences: Application of the Experience Sampling Method to the Web Environment,* 1998, Proceedings of WebNet 98 -- World Conference of the WWW, Internet, and Intranet, Orlando, FL.

Csikszentmihalyi, M. 1990, *Flow: The Psychology of Optimal Experience*, Harper and Row, New York.

Csikszentmihalyi, M. et al., 1997, *Talented Teenagers: the Roots of Success and Failure,* Cambridge University Press, Cambridge.

Dey, A.K., 2001, *Understanding and Using Context*, Personal and Ubiquitous Computing, Vol. 5, No. 1 pp. 4-7.

Finernan, C. and Zhang, P., 2002, *The Challenges of Studying Flow Within a Computer-Mediated Environment*, Eight American Conference in Information Systems, Dallas, TX, pp. 1047-1054.

Ghani, J.A., and Deshpande, 1984, S.P. *Task Characteristics and the Experience of Optimal Flow in Human-Computer Interaction*, The Journal of Psychology, Vol. 128, No. 4, pp. 381-391.

Henze, N. and Nejdl, W., 2001, *Adaptation in Open Corpus Hypermedia*, in P. Brusilovsky and C. Peylo (eds.), International Journal of Artificial Intelligence in Education, Special Issue on Adaptive and Intelligent Web-Based Systems 12.

Konradt, U. et al., 2003, *Flow experience and positive affect during hypermedia learning*, British Journal of Educational Technology, Vol. 34, No 3, pp. 309-327.

Papert, S., 1993, *The Children's Machine: Rethinking Schools in the Age of the Computer*, Basic Books, New York.

Patten B. et al, 2006, *Designing collaborative, constructionist and contextual applications for handheld devices,* Computers and Education, Vol. 46, pp. 294-308.

Pearce, J. (2005). Engaging the Learner: *How Can the Flow Experience Support E-learning*? In Richards, G. (Ed.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, pp. 2288-2295, Chesapeake, VA.

Pilke, E.M., 2004, *Flow Experiences in Information Technology Use*, International Journal of Human-Computer Studies, Vol. 61, pp. 347-357.

Shield, G., 2000, *A Critical Appraisal of Learning Technology Using Information and Communication Technologies*, Journal of Technology Studies, Vol. 26 No. 1 pp. 71-79.

Steels, L.and Tokoro, M., 2004, *A Learning Zone of One's Own*, IOS Press. Amsterdam.

Weber, G. and Brusilovsky, P., 2001, *ELM-ART: An Adaptive Versatile System for Web-based Instruction*, International Journal of Artificial Intelligence in Education, 12, pp. 351-384.