INVESTIGATING THE INSTRUCTIONAL VALUE OF PERFORMANCE SUPPORT SYSTEMS

Martyn Wild

Senior Research Fellow (Imago Multimedia Centre)
School of Management Information Systems, Edith Cowan University.
email: m.wild@cowan.edu.ai

ABSTRACT

This paper will report the findings of a study to investigate the value of a Performance Support System (PSS) for novices undertaking a complex cognitive task (lesson planning), within an innovative instructional model. The intention of the research was to investigate the value in using performance support as a strategy for engaging learning, by describing how learning might occur as a result of using a specific PSS. This notion is certainly in keeping with desirable trends in research into instructional technologies, where it is considered more appropriate to inquire into the processes of use rather than comparative measures of effect, of various media and technologies.

The idea of electronic performance support is new in the context of teaching and learning, and subsequently there is a need to understand the processes at work in learners' use of these technologies. Developing such an understanding will enable educationalists to refine their design, implementation and management of electronic performance support software for teaching and learning within complex domains.

KEY WORDS

Performance support, EPSS, hypermedia, cognitive tools.

1. INTRODUCTION

The rationale for this research lay in the paucity of instructional design models or approaches for the development of educational software products, particularly for tertiary education. Furthermore, it was completed in the shadow of seminal comments by Brown (1994), and Park and Hannafin (1993), amongst others, which are proving increasingly representative of the field of instructional technology, and which strongly advocate the need for new and better informed (ie. by a greater diversity in research findings) instructional design models.

The nature of the research was to hypothesise the value of using a model of instruction based primarily in the theory of cognitive tools and in the design methodology of (electronic) performance support systems (PSS), but also taking appropriate account of other cognitivist principles in instructional design, such as mental models, situated cognition and authentic learning. There were four orientations to the wider research programme:

1. Identify the critical components of a PSS to support the completion of a complex task (lesson planning).

2. Design and construct the Lesson Planning System (LPS) based upon those critical components considered to be relevant to lesson planning.
3. Investigate how novice student-teachers engage these components in the LPS to produce a lesson plan.
4. Investigate the effectiveness of the LPS as a PSS to support the completion of lesson planning.

This paper reports only on the third orientation. The space allowed for this paper here, prohibits a full reporting of the data collected in this study, even for its third orientation. However, the author intends to submit further articles reporting on other aspects of the study to refereed journals and conferences.

2. PERFORMANCE SUPPORT SYSTEMS

A Performance Support System is interactive software that is intended to both train and support the novice user in the performance of tasks. Raybould describes a PSS, rather widely, as a "computer–based system that improves worker productivity by providing on-the-job access to integrated information, advice and learning experiences" (Raybould, 1990).

Raybould (1996) has since elaborated on this, making reference to an evolving design methodology, which places emphasis on performers *in* systems rather than users *of* systems:

> An EPSS is the electronic infrastructure that captures stores and distributes individual and corporate knowledge throughout an organisation in order to enable workers to achieve the required level of performance in the fastest possible time and with minimal support from other people. Performance is achieved by designing the computer/ human interface using the principals of Performance-Centered Design (PCD), which focuses on the audiences as performers of work, rather than as users of a system. (Raybould, 1996)

However, for others there exist slightly different perspectives of PSSs, each moulded by small shifts in emphasis. For example, Barker and Banerji (1995) stress the problem-centred focus of PSSs, whilst McGraw (1994) characterises PSSs in terms of their facilities, noting their integration of AI technologies, hypermedia and CBT. PSSs can also be described in terms of the uses made of them – that is, in addition to their role in instructing and supporting novices, they might be used by those more experienced in the focus tasks to increase efficiency and quality of output, for example, by serving as amplifiers of experience and knowledge (Gery, 1991).

Traditionally, however, PSSs have been characterised by their structure and the software resources they provide, and these are usually determined to include: an information base (eg. on-line reference and help facilities and case history databases); interactive and learning experiences; productivity software (often used with templates and forms); and, an advisory system (eg. coaching facility) (Gery, 1995).

3. CONSIDERATIONS IN DESIGNING THE LPS

There were a number of considerations to make in designing the LPS, so that it might function as a performance support system in the manner described by Brown (1996) and others. The first consideration is that it should provide electronic support for the task of lesson planning. In the LPS, such support is provided in the form of explanatory help (for example, how to go about the procedural aspects of planning lessons), descriptions (for example, what experts view as important in lesson planning), and customised templates (for example, of lesson plans) and a number of databases (for example, of verbs to use in writing lesson objectives). In these ways, support in the LPS is both conceptualised and implemented to provide an instructional framework for use in the task of creating a lesson plan, comprising:

- descriptive or declarative information (eg. 'a lesson plan consists of learning objectives, processes and evaluation . . .');

- explanatory information (eg. ‘it is necessary to evaluate a lesson to determine how we might improve later lesson plans, and to measure the level of success in this one . . .’); and,
- procedural information, (eg. ‘to create a lesson plan you need to complete four steps describe your learning objectives, work out the best way of meeting these objectives . . .’).

Secondly, any support provided in a PSS needs to be made accessible at the time of need – a concept often referred to as ‘just-in-time’ support (Brown, 1996; Geber, 1991; Gery, 1991 34), or, as in more traditional software applications, on-line help (Sellen & Nicol, 1990). In the LPS such support is provided as information directly related to the task being undertaken and in a format expected by the student. For example, this might be a sequence of instructions to support the completion of a procedure; or it might take the form of a database of possible objectives for selection and placement into a lesson plan. The range of supporting information available in the LPS is partly tailored according to the on-line help that Sellen and Nicol (1990) suggest should be available in all software applications, to cover questions that are (i) goal-oriented, (ii) descriptive, (iii) procedural, (iv) interpretive, and (v) navigational.

Thirdly, the LPS needs to be integrated in the work environment, so that the task and the PSS are tightly linked. In the LPS, this is achieved by users being able to move freely between both performance and instructional support functions within the LPS operating environment. A more tightly integrated PSS might provide for partial or fully automated error trapping, to detect inconsistencies in any of the data being provided in lesson plan designs. For example, it might be that there are identifiable inconsistencies between (types of) lesson objectives and lesson evaluation strategies, devised in a single lesson plan. Such detection would necessitate the application of software intelligence in the manner described by Self (1990). However, it is currently not feasible, especially for small projects such as the LPS, to design technology applications to facilitate complex cognitive functions such as reflection, directly – this requires the development of sophisticated intelligent tutoring systems.

Finally, the appropriate use of technology is provided for in the LPS, so that its suite of functions may operate on a standard desktop or laptop computer (Apple Macintosh, running operating system 7.1, or greater, with 4 MB of RAM). The technologies in the LPS are presently focused on hypermedia driven informational support and performance tools. It is likely that further enhancements of the LPS might be towards offering greater information currency, where the user may link, on-line, to a wider range of relevant information using distributed information networks available via the Internet. It may also offer multimedia information.

4. THE CONTEXT OF DESIGN FOR THE LPS

At the core of the LPS is a model of lesson planning required by Edith Cowan University, Western Australia, and wider afield. This model includes essential components of lesson planning such as writing learning objectives, developing learning experiences and planning evaluation (Barry & King, 1993). Each component is supported by activities that instruct the user about the task (eg. provision of information relating to reasons why objectives are necessary, criteria for quality objectives), and which also assist the user in performing the task (eg. provision of a database of verbs to assist in writing quality learning objectives). A set of software tools is available to support each activity. One of these, for example, is a tool designed to engage students’ reflective thinking, and aimed at providing them with the ability to evaluate the effectiveness of their completed lesson plan. This tool functions by prompting students to analyse and reflect upon the appropriateness of evaluation processes set in relation to lesson objectives.

Table 1 below, describes the functions incorporated in the LPS, as either instructional or performance components. It is in terms of use of these components, that the LPS has been designed specifically, to support novice lesson planners in their performance of the lesson planning task, to better their performance, their performance outcomes (ie. their lesson plans) and also their learning in the task.

Table 1: Components in the LPS

LPS Components	Cognitive Act	LPS Functions
Instructional Support	Learning	Lesson Structure Effective objectives Evaluating learning outcomes Preparation Ways of writing the lesson plan Evaluating self What is a lesson plan? What is a good objective? Planning methods Using the LPS How do I ensure my evaluation will be effective? Reflection
Performance Support	Task performance	Verb Database Example Lesson Plans Work Pad Example Objectives Example Evaluation Processes Find Print

5. PROCEDURE

Four students, two male and two female, were identified to provide the focus for studying their patterns of LPS usage over a two week period. These students were volunteers and self-confirmed novices in lesson planning. The students were tutored in the use of the LPS, to the point at which they felt comfortable with their skill in the use of the technologies (ie. computer and software use). Students then used the LPS to plan a minimum of six lessons, over a period of two weeks – producing these lesson plans so that they might be implemented in their professional practice placement schools (to which they had already been assigned).

Observational data was collected by video tape recordings, providing a complete record of use of the LPS for each student for each session of use. From the observational data, it was possible to determine a count of students' interactions with instructional and performance components of the LPS, and the amount of time it took for them to complete the lesson planning task using the LPS. Also, from this data, an instructional-performance (IP) coefficient has been calculated to more effectively represent the changing nature of LPS usage over all lesson planning tasks. This coefficient is calculated by dividing the total number of instructional (I) interactions for each lesson plan, by the corresponding number of performance (P) interactions. For example, an equal number of instructional and performance interactions for one lesson plan, would provide an IP coefficient of one (1). Whilst there is no optimum IP coefficient indice, when calculated over a range of lesson planning tasks, for each student-teacher, the IP coefficients can provide an indication of the development of expertise in students' lesson planning skills.

Individual follow-up interviews conducted at the completion of the two week period, helped determine how all students managed aspects of the lesson planning task. Interviews were conducted one-to-one, and comprised a series of open questions which sought to identify how students perceived they completed the lesson planning tasks, and probed why students performed and managed the task in the manner they described. The sixth and final video tape recorded for each student, was played back to the student at this point, to elicit a delayed think-aloud procedure, acting as a prompt for each student to offer explanatory comment on their actions and behaviours in using the LPS, over the whole period of use. Interviews were held once for each student, and at the completion of the two-week use period (ie. within 10 days of the completion of the final lesson plan observed) so that students could also be asked to reflect on the lesson planning tasks as a whole, addressing the notion of change.

Further, each of the six lesson plans produced was evaluated by an expert lesson planner (ie. lecturer or teacher), as a measure of product quality; and, as a means of gaining an indication of the strength of transfer in students' learning over media, these lesson plans were then compared to a lesson plan produced by each of the students by 'pen & paper' means, following their use of the LPS.

6. RESULTS

Taken together (see Table 2), all students over all six lesson planning tasks, the patterns in the data are more or less regular. The decrease in use of instructional components was consistent and gradual over the six tasks (29–16, or 44.8%); there was also a corresponding increase, less rapid and less consistent, in the use of performance components over the same tasks (21–24, or 12.5%); and finally, we see a smooth, consistent and overall, very significant decline (ie. a difference of 20 minutes between the first and last task, or 51.3%) in the task times recorded.

Table 2: Lesson Plans 1–6

Lesson plans	LPS Components			Time (mins)
	Instruction (I)	Performance (P)	IP Coefficient	
L1	29	21	0.7	39
L2	24	22	0.9	35
L3	25	25	1.0	35
L4	21	24	1.1	23
L5	17	23	1.3	20
L6	16	24	1.5	19

Again, the average IP coefficient data for the entire group of students, demonstrates a clear and steady growth in use strategies, rising from 0.7 at task #1, and reaching 1.5 at task #6 in regular steps of 0.1 or 0.2. Figure 1, also reveals a clear and strong interaction in the composite data, occurring just before task #3, with the diverging data patterns thereafter clearly marking the reaching of, and a strong development in, expertise.

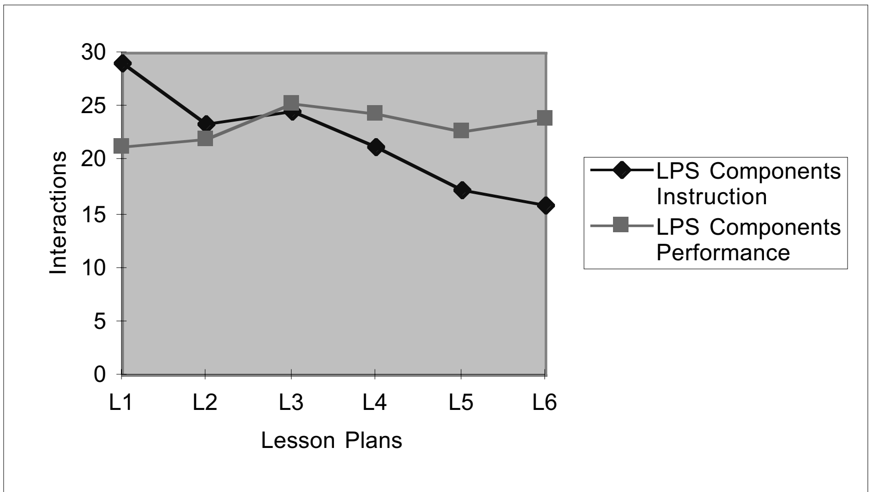

Figure 1: Lesson Plans 1–6

The temporal data for the students, when plotted on a single graph, shows that for all students, the time taken to complete a lesson planning task declined over the entire span of tasks (#1–#6). Also, for most students, this pattern of reduction is almost identical: starting at or near 39–40 minutes for the first lesson planning task; falling to around 35 minutes by the second task; holding steady for the third task, and then falling rapidly for the fourth task, before adopting a more gradual and even decline for the fifth and sixth tasks. Of the two students (3, 4) who did not conform to this pattern, neither is entirely out of sympathy with the broader design. Indeed, student 3 follows a similar temporal data pattern as the majority of others in this sample, except that she starts at a higher point, only to decline more rapidly at task #4, to come back into line with the others; whilst student 4, joins the broader pattern by the same task (#4). The data for all students increasingly converges over the last three lesson planning tasks, so that all students complete the final task in approximately 19 minutes.

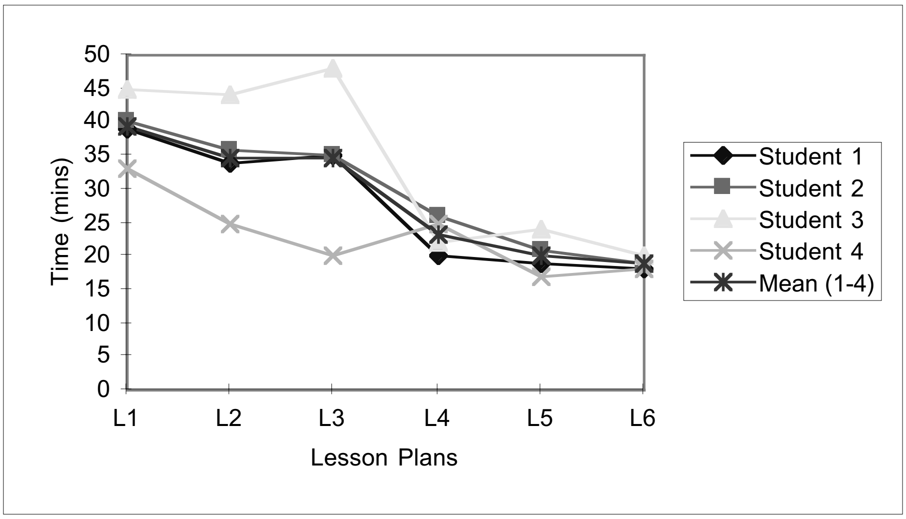

Figure 2: Time taken for task completion in the LPS for Lesson Plans 1–6

Generally, the patterns revealed in the interactions and the task-time data for these four students over all six lesson planning tasks, tell a remarkably similar story – decreases in use of instructional components, less significant and less consistent increases in the use of performance components; and dramatic reductions (ie. up to 56%, with an average of 51.2%) in the time taken to complete the tasks. It is in the IP coefficient data that we find the most consistent patterns: all students develop from below the 1.0 mark (approximately 0.7) in the initial task, to reach up to 1.9 by the closing task; and on average, all students experience a growth of 0.8 over this span of tasks.

When this data is matched with that revealed in Figure 1, we can see that on average, the students develop and sustain a level of expertise in their production of lesson plans, beginning at, at or very near the third lesson planning task. Indeed, Figure 1 shows an interaction in the data at these points, revealing the stage at which the students have a ratio in the use of instructional:performance components, of one.

6.1 INTERVIEWS

Interview data allowed for the richer documentation of students' cognitive processes and also increased accuracy (reliability) in interpretations offered in analysis of the video data. Whilst there is not room here to provide a detailed account of the analysis of each student's interview, it were clear from these analyses (Wild, 1998) that the LPS supported a range of cognitive strategies, including that based in 'value adding', where there was clear benefits to be had from being able to word process to a template, to be prompted to check aspects such as lesson evaluation, and also to be able to provide well-formatted print-outs of lesson plans. There is additional evidence that students came to see their use of the LPS as a scaffold, which could be removed “once you know what to do” (quote from student interview data). Furthermore, most students clearly evolved a confident, reflective and critical practice in their lesson planning, as part of the process of using the LPS. This is illustrated well in the statements:

> . . . this is the hardest thing to do, to keep changing the way I can tell how children were learning or not. You can’t have tests all the time, or work-sheets to tell you if they are learning, I know that . . . And what about individual children, I mean I had two kids who found writing really difficult, and I had to set them special things to do, making sure they were working but also keeping up with the progress of the rest of the class. This was really hard going. Its so easy to sit back and just let the kids, the whole class, get on with things, like doing a work-sheet, without knowing how some kids cope with it. You really have to plan for the range of abilities. The program was good at this, I could check how to do this when I realised what a problem it was; I could check the way to go about doing this – it was all there, in the program.

And also:

> I spent a lot of time at the end of these weeks, thinking about the lesson, not working out how to do it but thinking about what the kids were supposed to be learning, how I was trying to get them to learn something. And like what I was saying before, thinking about individual kids in the class, those two or three kids that struggled with things. The teacher really helped me here. But I learnt a lot from the program, the information its got on working with groups of kids and setting out different ways of teaching the same thing to different kids. It would have been good if there had been more examples of this sort of thing – all the lessons, the examples, are from easy lessons, from teaching the whole class...

A number of other factors arise in the interview data to shed some light on the development of students’ cognitive strategies in making use of the LPS. For example, there is evidence of high task involvement, to a point where at least one student remains largely unconscious of the ways in which he is actually using the LPS in task completion. There are also other instances where high task involvement might provide a credible explanation for certain student behaviours – such as with the second student who is unaware of the increased skill base the use of the LPS has provided her, and the increasingly automated approach she takes towards some of the lesson planning sub-tasks.

There are some common elements to the strategies employed by all four students: for example, initially exploring and accessing instructional information; working from previous lesson plans as templates for later ones; automating approaches to certain sub-tasks, such as writing lesson objectives; spending increasing amounts of time in higher-order sub-tasks which require reflection (ie. matching learning objectives to evaluation processes); and, actively seeking ways to produce lesson plans more efficiently, and in particular, more quickly.

It is likely that students’ motivations could provide at least part of the explanation for the development of their respective cognitive strategies. For example, the motivation to develop their independent skill base in lesson planning; or to obtain better marks for their lesson plans; or to teach better. There is evidence of all these motivational forces in the student-teachers here.

6.2 LESSON PLAN PRODUCTS

All lesson plans created by student-teachers here were subject to grading by expert reviewers at Edith Cowan University. Six grades were used; and, for use in providing a graphical representation of data in Figure 3, below, the grades F–A were each articulated to a numerical equivalent (ie. a mark), 1–6.

Table 3: Articulation of Lesson Plane Assessment: Outcome–Grade–Mark

Outcome	Grade	Mark
Outstanding	A	6
Outstanding	B	5
Highly Competent	C	4
Highly Competent	D	3
Competent	E	2
Unsatisfactory	F	1

The grades for each of the four students in the first six lesson plans, show an improvement of at least one grade, and for three of the students (1, 2, 4) one major grade category (ie. from Competent to Highly Competent, see Table 4, below). In the case of one student (1), there was an improvement of three grades spanning the six lesson plans assessed.

Table 4: Grades for Lesson Plans (Shaded areas indicate those lesson plans produced by means of 'pen & paper')

	Students 1–4			
Lesson plans	**Lesson plan grades**			
	Student/1	**Student/2**	**Student/3**	**Student/4**
L1	E	E	D	E
L2	D	E	E	E
L3	D	E	D	E
L4	D	D	D	D
L5	C	C	B	D
L6	B	D	C	D
L7	C	C	C	B

The first student (1) demonstrated a steady development in their grades, over all six lesson plans; the second and third students (2, 3) fluctuating in their grade attainment between the fifth and sixth lesson plans (2), and between the first and second and fifth and sixth lesson plans (3). The fourth student (4) increased their assessment by one grade, between the third and fourth lesson plans and maintained this grade for the remaining three lesson plans produced.

The improvement in grades achieved by the student-teachers between the first and sixth lesson plans assessed, was also maintained by three (2, 3, 4) in a seventh lesson plan produced by means of 'pen & paper' and without the support or use of the LPS. The remaining student (1) witnessed a decline of one grade over the two media, from Outstanding (B), to Highly Competent (C). In one case (4), the student not only maintained their initial improvement in grade assessment, but also bettered it by gaining two grades in the seventh lesson plan. The movements in grades for all students over the seven lesson plans assessed can be seen in Figure 3, following.

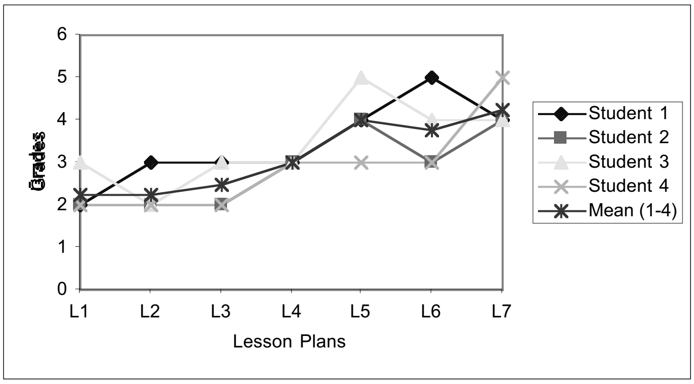

Figure 3: Grades for Lesson Plans 1–7 (where 1–6 corresponds to F–A)

Table 5, below, reveals the range of average grades achieved by students in this study, for all seven lesson plans, together with the mean grades, calculated over all lessons (L1-L7) and for all students (1-4). Whilst the grades achieved by each student do not follow a continuous path of improvement, the similarity in the standard deviations for the range of lesson plans, L1–L7, suggests that similar degrees of growth were achieved in lesson plan quality by all students.

Table 5: Grades for Lesson Planes 1–7 (where 1–6 corresponds to F–A)

Lesson plans	Lesson plan grades				
	Student 1	**Student 2**	**Student 3**	**Student 4**	**Mean (1-4)**
L1	2	2	3	2	2.3
L2	3	2	2	2	2.3
L3	3	2	3	2	2.5
L4	3	3	3	3	3.0
L5	4	4	5	3	4.0
L6	5	3	4	3	3.8
L7	4	4	4	5	4.3
Mean (L1-L7)	3.4	2.9	3.4	2.9	3.1
St. Dev.	1.0	0.9	1.0	1.1	0.9

7. CONCLUSION

The study reported here illustrates how novice students used the LPS in a complex task (lesson planning) to reach levels of expertise in the completion of that task; and further, were able to continue to call on this newly acquired skill and knowledge base to complete the same type of task without use of the LPS. Whilst there are a range of cognitive strategies by which novice students developed expertise in their performance of lesson planning, it would seem that all students here benefited in particular from active participation in an holistic, complex yet supporting environment, organised around a single performance goal.

Furthermore, these students evidently found considerable cognitive support in the LPS, when this support was most needed. Indeed, it is a basic tenet for the design of PSSs as well as a manifestation of the principle of just-in-time learning, that instructional information is made available at the point of need, and that time lags between task instruction, task practice and task performance are minimised or at best, removed. Furthermore, characteristics of various theories in cognitive psychology, share the same tenet –≠this is true of information processing, situated cognition and cognitive apprenticeship. Certainly, as Harmon and King (1979) point out, if learners are provided with information as they need it, they are more likely to make connections between the information and the context in which it is to be used. But of course, not all students will necessarily make meaning, particularly in complex aspects of tasks such as lesson planning, at the point of completing the task – or at least, not straight away. In one case here, for example, a student (2) imposed a learning strategy that she had used repeatedly in other learning situations, of re-reading instructional information so that it might be better understood, feeling more secure away from the task, when she has time to reflect more fully on the information. It seems that for this student, being too close to the performance of the task is a barrier to being able to appropriately reflect on related information.

It would seem that whilst PSSs like the LPS, are well-placed for consideration as an alternative instructional model, not all students will be in a position to make the best use of them. The learning strategies brought by individual students to the learning experience, and that exist independently to the task itself, are among the stronger determinants of the potential value of software such as the LPS as an alternative instructional model.

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