# The design dimensions of e-learning

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The currently popular term e-learning is shown to have several meanings which confuse discussion about a new technology which is finding widespread international use in a range of educational sectors. This paper analyses the characteristics of e-learning applications, and proposes a set of four design dimensions which could be considered when designing and assessing the suitability of e-learning applications. The applicability of the four proposed dimensions, and their shortcomings, are discussed in detail, and found to be justifiable.

**Keywords:** design dimensions, e-learning, educational technology

## Introduction

Computers have been used for education and training since the 1960s, and increasingly since the 1990s. Large and increasing amounts of money have been spent all over the world on the development of computer applications designed to help people learn. In the 1990s, courseware tended to be authored as a multimedia rich, monolithic application, developed to suit one specific need. This approach made it expensive to adapt material to other purposes and to update it for changed information. With the advent of the world wide web in the late 1990s, it became possible to develop courseware (web sites) which were much more adaptable, and less expensive to create, but which lacked the educational and multimedia richness of the earlier monolithic applications.

Shortly thereafter, the first learning management systems appeared on the market. These applications delivered web pages to students and provided online interactive tools whereby students interacted with course materials and other students and their teachers, but largely in a text based way.

Bandwidth increases in the early 2000s enabled effective interaction and multimedia capabilities to be provided over the web. At the same time, the 'learning object' movement started to gain momentum, driven largely by the US military's requirement to provide reusable and repurposable training content for its staff, independent of the computer system one is using (Advanced Distributed Learning, 2003).

While a large number of terms has been used to describe the range of these computer applications, the currently popular term is e-learning. However, there is confusion about what e-learning means in different contexts. For several years, proponents of educational technology have been using terms like e-learning in a 'one size fits all' manner. While there are distinctive differences between, for example, a use of a simulation learning object as part of a laboratory session, a corporate training CD and a tertiary course offered solely online to international students, these are each referred to as e-learning, to the confusion of practitioners and policy makers alike.

It can be argued that e-learning is an inappropriate term to use in any case, because it implies that the computer system can *deliver* learning or cause learning to occur. This flies in the face of research about learning, which shows that learning is a cognitive process which occurs internally, but which is impacted on by a number of environmental factors. Despite its semantic inaccuracy, this paper will continue to use the term e-learning, because it is currently widely accepted.

This paper attempts to resolve confusion about various types of e-learning, by analysing the nature of various e-learning products in terms of four design dimensions. Previous work (Reeves, 1997; Reeves & Harmon, 1994; Reeves & Reeves, 1997) has analysed the nature of 'interactive learning systems' and 'interactive learning on the WWW' in terms of a number of dimensions deriving from personal paradigms of knowledge. Further work by Bain, McNaught and colleagues investigated the impact of teachers' beliefs on the design of e-learning (Bain, McNaught, Mills, & Lueckenhausen, 1998a, 1998b; Kennedy & McNaught, 1997).

**Table 1: The four e-learning design dimensions and their range**

| Dimension | Extremes | |
|---|---|---|
| Student student interaction (SS) | Individual | Social |
| Student teacher interaction (ST) | Present | Absent |
| Student resource interaction (SR) | Traditional | Digital |
| Student computer interaction (SC) | Passive | Interactive |

The design dimensions proposed here are not related to the designer's belief systems. Instead, they are based on the interactions that a student may have in a technology supported learning environment. These are summarised in Table 1.

Making decisions about these four interactions is an important factor in the educational design process associated with any e-learning development. The four dimensions are discussed in detail below.

## Four design dimensions

### Student student interaction

The interaction between a student and other students in an e-learning environment is one dimension. Bransford, Brown, & Cocking (1999) conclude that participation in social practice is a fundamental form of learning, so the ability for students to communicate and interact with each other is an important factor in e-learning design. Educational researchers in the field of computer mediated communication have been promoting and demonstrating the benefits of collaborative learning online for many years (Collis, 1996; Harasim, Hiltz, Teles, & Turoff, 1995; Paloff & Pratt, 1999). A special issue (19(2)) of the Australasian Journal of Educational Technology provides a more recent exploration of this issue.

However, in some cases, because of commercial pressures, or lack of internet connectivity, it is not feasible to include human contact as part of the learning activities in the design of e-learning, and students are required to work individually.

The student student (SS) interaction dimension varies between individual and social work, as shown in Table 1. Clearly, this dimension is continuous rather than dichotomous, because in many learning situations there will be a mixture of individual and social work.

### Student teacher interaction

While in some cases, e-learning is designed for a target audience distant from an educational institution, Gartner Group research indicates that university e-learning materials are predominantly used as a supplement to traditional face to face teaching (Harris, Yanosky, & Zastrocky, 2003), in what is called variously mixed mode, blended or flexible learning environments (Lefoe & Albury, 2004). This work was reaffirmed by a survey of online units of study offered at Australian universities (Bell, Bush, Nicholson, O'Brien, & Tran, 2002). Of 63,468 units of study offered online, only 0.8% had no face to face component.

A second dimension is therefore the student teacher (ST) interaction, one extreme of which is that the teacher is present and has face to face contact with the student. On the other hand, some e-learning applications are designed to be used in a completely self paced manner, where the teacher is absent. This is the other extreme. A further example close to this end of the ST dimension is in distance learning, where the teacher may have little interaction with the student other than marking submitted work.

Once again, the dimension is continuous, because there may be varying amounts of teacher contact in different learning contexts.

### Student resource interaction

While in many cases an assumption underlying e-learning is that learning resources (content) will be delivered by ICT, either online or on some other medium such as CD, this is not always the case. It is

possible to participate in e-learning activities without obtaining resources via ICT. For example, students may obtain curriculum content through traditional means (on paper or through attending lectures), but conduct learning activities, such as quizzes and discussions, through e-learning. Furthermore, a distinction is made here between resources designed to lead to learning and course administrative information, which is excluded from the analysis.

The third dimension is therefore the student resource (SR) interaction, the mechanism by which students receive curriculum content. The extremes of this dimension are traditional (through print, lecture or other means) and digital (through any sort of ICT mediation). This dimension is also continuous because it is possible to have various amounts of content available through either means, or even both.

It is arguable that it is more appropriate to provide volumes of reading material to students in print format, because it is more convenient, and research indicates (Troffer, 2000) that current screen resolutions make it easier to read on paper.

### Student computer interaction

The fourth dimension is the extent to which the e-learning design enables students to interact with the computer in carrying out learning activities. Many e-learning designs enable substantial interaction between student and computer, and this is one extreme of this dimension. See, for example, Reeves & Hedberg (2002: 8-11).

In other cases, computer activity is restricted to the functionality of the web browser which enables students to progress to another page of text. This type of interaction is viewed as a navigational activity not a learning activity, and the role of the computer is deemed to be passive.

The extremes of this dimension are passive and interactive. This dimension is clearly continuous, because there are levels and degrees of interactivity, as identified by Sims (1997; 2000). In our case, to be classified as interactive, an e-learning application needs to respond meaningfully to students with feedback, rather than taking them to other content.

It is useful to consider various examples of interactivity commonly available in e-learning applications. Navigating between pages of content in a web browser or learning management system is clearly passive, while using a computer simulation is clearly interactive. Online quizzes and self tests are interactive, because feedback is provided as a result of the student's actions. However, the use of an online discussion forum is regarded as passive, because the interaction is in another dimension, between student and student, and the computer use is navigational.

## Interactions of the four design dimensions

Given these working definitions of the four design dimensions, a further analysis was performed on how the four dimensions interact with each other in characterising different e-learning environments. Table 2 lists the 16 possible combinations of design dimensions, and provides a typical scenario for each. A short hand notation was developed to easily identify each dimension. This is shown graphically in Fig. 1, where each column corresponds to one of the four dimensions, and the second and third rows correspond to the extreme values of each dimension shown in Table 1. The initial letter of each extreme is shown in each box in Fig. 1.

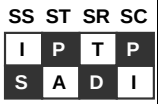
| SS | ST | SR | SC |
|---|---|---|---|
| I | P | T | P |
| S | A | D | I |

**Figure 1: Graphical shorthand notation for each of the extremes of the four e-learning design dimensions**

The analysis summarised in Table 2 indicates that each combination is logically distinct, and has a plausible example, even though some are likely to be more common. This indicates that the four design dimensions are independent of each other (orthogonal in the mathematical sense).

**Table 2: Analysis of the 16 combinations of the e-learning design dimensions with examples**

| | Student student interaction | Student teacher interaction | Student resource interaction | Student computer interaction | Description | Scenario |
|---|---|---|---|---|---|---|
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Present | Traditional | Passive | Student works alone<br>Teacher teaches face to face<br>Notes and resources obtained from lectures or in print<br>Computer use is passive | Traditional, on-campus teaching and learning environment with static information, such as administrative details and study schedules on computer.<br>This approach is common, but arguably is not e-learning. |
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Present | Traditional | Interactive | Student works alone<br>Teacher teaches face to face<br>Notes and resources obtained from lectures or in print<br>Student does interactive computer work (simulations, quizzes) | Traditional, on-campus teaching and learning environment supplemented with interactive computer work.<br>This approach is relatively common. |
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Present | Digital | Passive | Student works alone<br>Teacher teaches face to face<br>Notes and resources available digitally<br>Computer use is passive | Traditional, on-campus teaching and learning environment except that notes and resources are available online. (Blended learning)<br>This approach is widespread. |
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Present | Digital | Interactive | Student works alone<br>Teacher teaches face to face<br>Notes and resources available digitally<br>Student does interactive computer work | Traditional, on-campus teaching and learning environment except that notes and resources are available online and study is supplemented with interactive computer work.<br>This approach is relatively common. |
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Absent | Traditional | Passive | Student works alone<br>Minimal teacher involvement<br>Notes and resources obtained traditionally<br>Computer use is passive | Traditional, print based distance education model with static information, such as administrative details and study schedules on computer.<br>This approach is uncommon. |
| SS ST SR SC<br>I P T P<br>S A D I | Individual | Absent | Traditional | Interactive | Student works alone<br>Minimal teacher involvement<br>Notes and resources obtained traditionally<br>Student does interactive computer work | Traditional, print based distance education model supplemented with interactive, self paced computer work, eg simulations on CD.<br>This approach is uncommon. |

| | | | | | | |
|---|---|---|---|---|---|---|
|  | Individual | Absent | Digital | Passive | Student works alone<br>Minimal or absent teacher involvement<br>Notes and resources available digitally<br>Content on computer is static | Traditional distance education model converted to online mode.<br>Standalone, content based corporate training delivered online or on CD.<br>Webquests and other online research activities.<br>These approaches are widespread. |
|  | Individual | Absent | Digital | Interactive | Student works alone<br>Minimal or absent teacher involvement<br>Notes and resources available digitally<br>Student does interactive computer work | Standalone, content based education and training applications containing interactive activities and delivered online or on CD.<br>These approaches are widespread. |
|  | Social | Present | Traditional | Passive | Students work collaboratively<br>Teacher teaches face to face<br>Notes and resources obtained from lectures or in print<br>Computer use is passive | Traditional, on-campus teaching and learning environment with static information, such as administrative details and study schedules on computer, but with online discussion forums.<br>This approach is relatively common. |
|  | Social | Present | Traditional | Interactive | Students work collaboratively<br>Teacher teaches face to face<br>Notes and resources obtained in lecture or in print<br>Student does interactive computer work | Traditional, on-campus teaching and learning environment supplemented with interactive computer work and online discussion forums.<br>This approach is relatively common. |
|  | Social | Present | Digital | Passive | Students work collaboratively<br>Teacher teaches face to face<br>Notes and resources available digitally<br>Computer use is passive | Traditional, on-campus teaching and learning environment except that notes and resources are available online and study is supplemented with online discussion forums.<br>This approach is widespread. |
|  | Social | Present | Digital | Interactive | Students work collaboratively<br>Teacher teaches face to face<br>Notes and resources available digitally<br>Student does interactive computer work | Traditional, on-campus teaching and learning environment supplemented with online content, online discussion forums and interactive computer work.<br>This approach is relatively common. |

| SS ST SR SC<br>I P T P<br>S A D I | Social | Absent | Traditional | Passive | Students work collaboratively<br>Teacher is distant from students, but may play a role as online facilitator<br>Notes and resources obtained traditionally<br>Computer use is passive | Online distance education model based on online discourse supported by print based content.<br>This approach is uncommon, but was used in computer mediated communications prior to the advent of the WWW. |
|---|---|---|---|---|---|---|
| SS ST SR SC<br>I P T P<br>S A D I | Social | Absent | Traditional | Interactive | Students work collaboratively<br>Teacher is distant from students, but may play a role as online facilitator<br>Notes and resources obtained traditionally<br>Student does interactive computer work | Distance education model based on online discourse supported by print based content and interactive computer work.<br>This approach is rare. |
| SS ST SR SC<br>I P T P<br>S A D I | Social | Absent | Digital | Passive | Students work collaboratively<br>Teacher is distant from students, but may play a role as online facilitator<br>Notes and resources available digitally<br>Computer use is passive | Online distance education model based on online discourse supported by online content.<br>This approach is common. |
| SS ST SR SC<br>I P T P<br>S A D I | Social | Absent | Digital | Interactive | Students work collaboratively<br>Teacher is distant from students, but may play a role as online facilitator<br>Notes and resources available digitally<br>Student does interactive computer work | Online distance education model based on online discourse supported by online content and interactive computer work.<br>This approach is uncommon. |

## Examples of the dimensions

To validate the usefulness of the four design dimensions, a number of instances of e-learning environments were categorised in terms of the dimensions.

In 2000, the Australian government Department of Education Science and training (DEST) carried out an audit of online education provision (Bell et al., 2002) at universities in Australia. Three definitions (including sub-definitions) were used, as shown in Table 3. The four design dimensions adequately distinguish between the 5 modes and sub-modes. Notice, however, that the latter two modes combine different aspects of interactions with the learning environment, with both individual and social work possible.

Several other examples of e-learning environments are analysed below in terms of the four design dimensions.

Learning objects developed for the schools' sector by the Learning Federation (Atkins, 2003; Lake et al., 2004) are designed for use in classrooms, with teacher guidance, and are classified as shown at right. While interaction between students was common when using these learning objects, this occurred mainly with pairs of students working on the same computer. While social work took place, this was not facilitated by the computer, so this is classified as an individual interaction from an e-learning point of view.

| SS ST SR SC |
|---|
| I P T P |
| S A D I |

Most CD based multimedia programs are classified as IADI, being designed for individual, self contained, self paced use. Interactive learning systems such as those described by Reeves and Hedberg (2002: 8-11), educational games such as SimCity 2000 and corporate training packages such as those

| SS ST SR SC |
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| I P T P |
| S A D I |

produced by corporations such as NetG all have the same classification, but with varying degrees of interactivity.

**Table 3: DEST online education definitions (paraphrased) and their characterisation in terms of the design dimensions**

| Online Mode | Dimensions |
|---|---|
| Mode A - Web Supplemented<br>Enrolled students can optionally access online information on units of study that is additional to that available in the university's calendar or handbook. E.g. course descriptions and study guides, examination information, assessment overview, reading lists and other online learning resources. | SS ST SR SC<br>I P T P<br>S A D I |
| Mode B - Web Dependent<br>Some face to face component with compulsory participation online in:<br>1. using the web to interact with the education content necessary for study | SS ST SR SC<br>I P T P<br>S A D I |
| 2. using the web to communicate with staff and/or other students | SS ST SR SC<br>I P T P<br>S A D I |
| 3. using the web both to interact with content and to communicate with staff and/or other students | SS ST SR SC<br>I P T P<br>S A D I |
| Mode C – Fully Online<br>All interactions with staff and students, education content, learning activities, assessment and support services are integrated and delivered online, with no face to face component. | SS ST SR SC<br>I P T P<br>S A D I |

## Discussion

The four design dimensions are intended to contribute to the design of e-learning applications, and to assist in decision making about e-learning applications through clarifying understandings about e-learning. They are not intended to be used to make judgements about e-learning effectiveness and how people learn with educational technology.

The four design dimensions are intended to be pedagogically neutral, with no judgement implied that one element of each pair is intrinsically more valuable than the other. Effective learning is possible in each of the 16 scenarios, although judgements about the rate of adoption of each approach (see Table 2) indicate that certain combinations are less likely to be effective. For example, the SATI combination, a traditional distance education model supported with online discourse and interactive computer work, was judged to be rare, but may occur in situations such as at the UK Open University.

Table 2 indicates that the sixteen combinations of dimensions are not all equally common. Four combinations are rare or uncommon, but the other 12 combinations are readily identifiable in various educational contexts, with four being widespread.

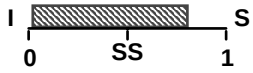
While the design dimensions appear to be fit for the purpose for which they were designed, further analysis has indicated that there are shortcomings in the representation of the four design dimensions.

### Shortcomings

The representation of the dimensions used in this paper, which highlights the chosen value, implies that the choice is dichotomous, with no way to represent values on a continuum, even though it has already been argued that each dimension is continuous. A second implication is that one value has to be chosen to the exclusion of the other value, and it has already been seen in Table 3 that this is not always the case. While the dimensions are continuous, the representation is not.

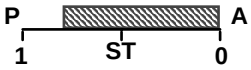
The nature of the continuity of each dimension is discussed below.

*Student student interaction*
It is unlikely that the student student interaction will be wholly social, but there can certainly be a mixture of both social and individual, and the interaction can be wholly individual. It is impossible for this interaction to be both wholly individual and wholly social. Mathematically, the function is continuous, showing a proportion of social work, starting at zero for Individual, as shown here.

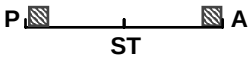



In terms of the representation shown in Fig. 1, judgements have to be made about which is the dominant characteristic. In cases where e-learning is designed to be both individual and social, both values should be highlighted.

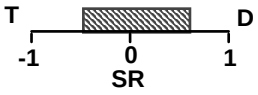
*Student teacher interaction*
There are two ways of viewing the student teacher interaction. In one view, the teacher's role can vary from present to absent, with varying degrees of presence, as shown here. In this sense, the dimension is continuous, expressing the relative amount of presence, with Absent equivalent to zero.



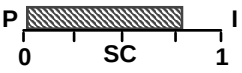

However, it is also possible to design an e-learning application to function in various teaching environments. For example, the SarcoMotion program (Fyfe, Fyfe, & Phillips, 1995; Phillips, Jenkins, Fyfe, & Fyfe, 1997) was designed to be used as an interactive lecture aid (P), and also as a self paced learning resource (A). In this sense, the function is dichotomous, and both the P and A elements should be highlighted.




*Student resource interaction*
The student resource interaction is different yet again. The Traditional and Digital scales move in opposite directions along the axis of the dimension. It is possible to conceive of a course with no learning resources, perhaps where learning was constructed from contributions made dynamically by students and their teacher. Moving from this zero point, varying amounts of traditional and digital content may be provided in both directions, as shown here. In fact both can be provided, and provision of both is arguably better than provision of one type only, because it provides more flexibility for students. In terms of the representation shown in Fig. 1, either one or both elements may be highlighted, as appropriate.




*Student computer interaction*
The student computer interaction scale adds more interactivity as you move along it. This continuous scale behaves analogously to the student student dimension, but levels of interactivity may be more easily defined.




These factors indicate that the representation of the four dimensions used here is not entirely accurate, but this raises the question about the need for them to be accurate.

While the continuity of the dimensions as been argued, the value chosen for any scale is currently subjective, and the value is not quantitatively justifiable. Similarly, the granularity of the e-learning application affects the ambiguity of the classification. A self contained learning object can be relatively unambiguously classified. However, an entire unit of study is likely to have mixtures of the different classifications, making it difficult to classify accurately.

Given these arguments, and the difficulty of representing the complexity of the dimensions on paper, the current representation is considered to be adequate.

The discussion above indicates that it is not logically necessary for a single value to be assigned to each dimension. In fact, the design of an e-learning environment may explicitly set out to accommodate multiple aspects of the dimensions. One example is the flexible learning initiative underway at the author's university (Phillips, Cummings, Lowe, & Jonas-Dwyer, 2004). In a bid to blur the boundaries between on-campus and distance education, a new unit of study model was developed which focused on student access to learning activities and resources, rather than on their enrolment mode. The characterisation of the new model in terms of the design dimensions is shown at right. Units are designed to be studied equivalently both on- and off-campus, with varying mounts of social contact, with the teacher either present or absent, and with the student choosing the types of resources they use.

| SS | ST | SR | SC |
|---|---|---|---|
| I | P | T | P |
| S | A | D | I |

## Conclusion

This paper has proposed four dimensions for analysing the design of e-learning applications and has considered in detail their applicability and their interactions with each other. It is concluded that the proposed dimensions are a useful tool in both designing and classifying e-learning applications, in order to have informed discussions about them.

Hopefully this paper provides a starting point for understanding the diversity of e-learning, and a platform for further discussion about an emerging field of inquiry.

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