What is needed for effective learning on the Internet?

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ABSTRACT
This paper discusses several flaws in learning, associated with Internet-based education at present. It also suggests an optimal method for conducting Internet-based education and how to accomplish it.

Keywords
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Introduction
We are currently seeing the development of very large amounts of Internet based learning material, particularly in the United States, for the World Wide Web, primarily for university and training, but also for schools. Many organizations have been created to help with such online development and the materials and organizations continue to increase.

Both traditional institutions and new forms of institutions, some for profit, are involved. Distance learning is the major goal, although some of this material is used in standard classes. We see little empirical consideration of the learning effectiveness of this material, unfortunately typical in education.

However, almost all of this material is weak in several critical features. This paper discusses these flaws, from a learning viewpoint. They reflect inadequate learning paradigms and developmental strategies, rather than problems with the Internet itself. We will then review a type of learning material for the Internet that can overcome these flaws, modeled after a tutorial approach to learning.

The origin of these problems comes partially from the fact that almost all online learning today is based on imitating what happens in the classroom, trying to recreate this environment in distance education. Yet, there are strong signs that the classroom, and the educational philosophy supporting it, is insufficient for twenty-first century students. It is a very old approach to delivering student learning. Mostly it comes today from large lecture sections, sometimes with discussion sessions and electronic support. Grades in most classes show that many students do not learn, or learn only incompletely.

I will not discuss this approach in detail. This existing system in schools, training institutes and universities is not an adequate beginning point for learning on the Internet, leading to the flaws mentioned next. In other papers, and in a forthcoming book, referenced at the end of this paper, I explain in more detail how these problems can be avoided, to create more effective tutorial distance learning material for the Internet for all students at reasonable expense.

Flaw 1 – The courses only work for small numbers

A major problem we face in learning today is increasing numbers of students. This is a United States problem and a world problem. We now have 6 billion in the world, predicted to be 9 billion in 2050. Predictions from the United Nations suggest a rapid rise in the medium age, also affecting our need for learning, and affecting the type of learning needed. Adult learning will be far more important than at present.

Many people have inadequate learning available, in every country. We have a billion illiterate adults in the world, most of them women, for example, many even in developed countries such as the United States. For many students little or no formal education is available. Students from poor families, worldwide including wealthy countries, have inferior education opportunities. It is not just a matter of having computers.
A recent report at the University of Illinois argued that the best class size for online courses is no more than twenty students. Discussions on listservs have been arguing for similar numbers. All these discussions are based on the current imitative courses. But groups of twenty will not solve our learning problems, given the large numbers of people on earth. They will not even solve the increasing needs for education even in countries like the United States.

These discussions of class size in distance learning have ignored such organizations as the UK Open University, which has successful ‘classes’ of over 10,000 students in distance learning environments, based on relatively primitive delivery technology (print and video) compared to what is possible today. It has been in operation for over thirty years. Similar institutions have been founded in many parts of the world (the megauniversities), but not in the Americas.

The approach at many universities now is certainly not the only form of distance learning. Current Internet learning activities are not based on empirical data about learning; they appear to be based on expediency, and a false sense of economy. Many different possibilities for distance learning are possible.

This myriad collection of distance learning types should be considered before deciding on a single, or several, systems. The book already mentioned discusses them. Experimental studies with large numbers of students are required to make rational choices as to the best form of distance learning for a given situation. These studies do not yet exist. Mostly, they have not even begun. We will discuss such studies later in this paper.

**Flaw 2 – Lack of adequate interactions with students**

Students need individualized help for effective learning, adapted to their individual needs. Current learning, both in classes and on the web, often assumes that the central task of education is the transfer of information to the student. But this view is not adequate for many students and for many areas. It does not easily lead to development of important higher cognitive skills, such as problem solving, intuition, and creativity.

The usual means of presenting the information to be transferred are by lecture, by video, and by print. For print either books or text-heavy Web sites are the common means. But these approaches do not allow for the individual differences between students, including backgrounds, interests, and learning skills. Weak methods are available, such as discussion sections and email, for giving some individualized attention. Grades show that these are inadequate for many students; some students do not learn or learn only partially. Current web sites also mostly follow this tradition, providing little individualized help.

We need in learning to be concerned with what the individual student does not know, what problems the student is having. We can find this with frequent high quality interaction with each student. Frequent means every few seconds, and high quality demands that the interaction should be, in both directions, in the student’s native language, our most powerful tool for communication. This means very little pointing and multiple choice on the part of the student, weak forms of interaction.

The student’s language is very important in this interaction. The computer can ask questions, looking for student problems, and students can reply in free form.

Our model from the past is the skilled tutor, working with individuals or small groups of students. We consider this further later. Voice input, now practical for tutorial computer-based learning will be the natural way to provide this high quality interaction.

To achieve this on the Internet, we need not be concerned with rapid two-way communication between student and the server computer. Perhaps the best strategy will be to download chunks of the code, perhaps entire program segments, to the local computer, and have the frequent interactions take place locally. This is similar to the Java Applet strategy already in use for other purposes. In spite of the frequent call for higher bandwidth, it is not clear that better learning requires higher transmission speed.

We need also to consider interactions with other students, peer learning. This receives little attention in current online courses, in spite of its valuable contributions to learning. Peer learning is an important component of learning. The learning units should stimulate it, bringing students together. Groups of about four are best, I believe, perhaps arranged electronically.
Flaw 3 – Learning is not available for many

Learning, particularly complete learning is not always available for many students. This is obvious for the billions of people on earth who have never used a telephone, and for the very poor billions. But it is even true in the developed countries. In spite of all attempts at equity in education, the poor are neglected, as are the women. Current online learning does little to improve this situation.

Flaw 4 – Insufficient storage of student information

Skilled human tutors start a session with a student with considerable previous experience, and they make use of this information to guide the tutorial situation. Current Internet systems store very limited student information, usually only to show overall progress and determining grades. They do not record information about student problems for later reference, for example. But computers can store information!

If we are improving learning at all we want much more detailed records for each student, gathered on a moment-by-moment basis as learning takes place. Information about student learning problems is particularly important. This stored information should be used, along with recent student responses and other information, to make decisions about what learning material to present next to each student. An important clue to what is needed for making this decision about what learning materials to present next comes from Lev Vygotsky’s concept of the zone of proximal development, suggesting what the student is now ready to learn.

Flaw 5 – Many students do not learn with existing materials

We need learning systems in which ALL students succeed, learn to the mastery level. Learning is necessary for individual happiness and for societal progress. We cannot afford to waste talent in the new century. Evidence indicates that mastery is possible for all in tutorial environments.

But the current online learning materials do not help all students to learn. Many students drop such courses, and other show only partial learning. Many are bored. Since these courses imitate existing standard courses that have these same problems, this is not surprising.

Flaw 6 – Learning is too expensive

Present online material, with twenty student groups each with an instructor, is too expensive for today. Further, it does not scale easily to much larger numbers. We need to consider new possibilities for learning that have more reasonable costs, if we are to solve our learning problems worldwide. These questions of cost cannot be ignored. The critical factor is not the cost of development, but the total cost to deliver an hour of high quality learning material to the student.

Flaw 7 – Insufficient consideration of lifelong learning

Most of the online material developed has been based on existing university courses, as we have noted. Current systems of learning focus primarily on students from about six to twenty-five years.

But the demographic data indicates that the center of learning is soon to move forward. Even today, the rapidly changing world continually demands new skills and new thinking, as we grow older. This trend will continue and accelerate. So we have the challenge of meeting this new need.

Why these flaws exist

As commented, these flaws are not due to the Internet itself, but are connected rather with the types of material developed thus far. They are modeled after current classroom approaches, with the major flaws indicated, such as lack of interaction.
We could have learning materials on the Internet with none of these flaws, with currently available technology. No new hardware or software is needed. However, vast development of a new style of learning material is necessary.

The essential factors as suggested are the learning paradigm employed, and the process for developing the learning units.

**Learning Paradigms -- Information Transfer**

Almost all learning today, including the Web courses we are considering, is based on an information transfer paradigm, as already mentioned. It sees the primary job of the student as acquiring information, and the courses using this strategy test primarily on memory of information or processes. It has ruled learning for thousands of years, although as we will note there has been another paradigm available.

We can see many signs of this paradigm for learning, as it affects the minds of the students. Lectures, textbooks, video, and textual web sites are the typical noninteractive media for affecting the transfer. Textbooks and notes heavily marked with yellow (usually) markers are one such sign. Looking how this is done with science and mathematics texts suggests that the publishers should print the books on yellow paper! Is anything unimportant?

Student interaction is rare. The student’s most common question is ‘will this be on the test?’ If it will not, most students will ignore it. Testing in large courses often uses inferior tactics such as multiple choice. Open book and note tests are seldom given, since memory is stressed. Another sign is the large amount of cheating that takes place with students, in spite of vigorous faculty efforts to control it.

**Learning Paradigms -- Tutorial Learning**

But there has been another paradigm for learning for a similarly long period, the tutorial paradigm. A skilled tutor works with one, two, or three students, in a highly interactive fashion, often mostly asking questions or discussing student assignments. Learning with this approach has been spectacularly successful. This has usually been the learning paradigm for the children of the wealthy, who recognize its superiority. Even rich dullards get college degrees this way. But it has been too expensive for most learning.

Today, however, the computer can play the role of the skilled tutor, at a very reasonable cost, and with very large numbers of students. This does not require artificial intelligence, although that may be useful in the future. Our group at the University of California, Irvine, has been developing such material for over thirty years, initially on hardware much more primitive than that available today.

The cost per student for computer-based tutorial material will eventually be less than the cost of traditional learning. We can reach in the near future almost everyone on earth with such learning.

Almost no full-scale computer-based tutorial material is available so far, however. A large research and developmental effort is needed to make tutorial learning with computers practical, as we will discuss later. The following developmental effort will be huge.

**Development of the learning material**

The processes used for developing material for information transfer is not adequate of developing tutorial computer based material. The focus needs to be from the very beginning of development on finding student weaknesses, and helping with these weaknesses. The ability of the program to do this is the function of the designers. This implies a structure for learning where the program is always looking for these problems.

Many such developmental systems will be possible. We have developed one such system at Irvine. The two most important stages in development are design and evaluation.

Excellent teachers or professors in the area involved do design in this system. We find that to get good interactive material these teachers should not design alone, but should work in groups of about four. Our
strategy for recording the design decisions is a ‘script.’ It shows all the details for the final program, including messages to the student, media details, how student input is analyzed, what program paths are followed, what student information is stored, and how the program uses stored information. The script is stored in the computer. Much of the code can be written from the script by the computer.

The designers are not perfect, and will miss some details. So extensive evaluation and improvement with typical intended users is important. Professional evaluators should design and execute this evaluation. This step is unfortunately overlooked or ignored with many developmental efforts. Current online courses very seldom have had an adequate evaluation.

Careful evaluation can lead to major improvements in the effectiveness of the learning modules. The computer can store much of the information for this evaluation. Mastery and motivation are key factors to examine.

Design is described in more detail in some of the papers listed at the end, and in the book soon to be published. This design procedure allows us to overcome all the flaws mentioned.

Costs

The development process is expensive, if we are to have good widely usable tutorial material. But this, although often emphasized, is not the critical cost factor. The important factor as already indicated is the cost for delivering an hour of excellent tutorial learning.

Many other factors besides development come into computing this important cost, varying from situation to situation. Most important are the costs of delivery and the numbers of students. For large numbers we can use delivery systems whose cost per student declines with the number of students.

We can learn about costs from the United Kingdom Open University. Their experiences over thirty years showed that material could be developed carefully, at considerable expense, and still provided at a low cost for students. As mentioned cost for a student hour of learning is the most important consideration regarding costs.

Two factors as mentioned are critical for affordable distance learning, an inexpensive delivery system and large numbers of students. With greater use of technology, and with tutorial learning material, we can have a much less expensive delivery system than the Open University has used, with its extensive dependence on individual tutors all over the country. Careful consideration needs to be given, with a new system, to total cost, including development, all aspects of delivery, and administration costs.

Again large numbers are a key to low costs, reducing cost per student if the delivery system is scalable. Other factors also need to be considered in a complete analysis of costs. A chapter in the forthcoming book referenced at the end of this paper discusses costs in more detail.

Research

As we have said, very little highly interactive computer-based tutorial learning has been developed. So many of the expectations expressed here are not demonstrated as yet. Further extensive research is needed. We should do this research. No other strategy known to me seems likely to overcome the flaws this paper began with. Only empirical data, not discussion or political considerations will demonstrate the usefulness of the system proposed. Other approaches might also be considered for such research.

To gather this data, we need a considerable body of learning material of the type described in this paper and in the references. It would be very desirable to have this material cover a wide range of student ages, from birth to old age. Further, material in several natural languages should be available; the same units can be moved to many cultures and languages. Several groups should be involved in this experimental development, to allow different developmental philosophies. Careful records of steps of development and cost for each project should be maintained, for later use in making developmental decisions.

After development of the first of these extensive segments, research efforts can begin. Groups experienced in such evaluations not involved in development should do this work. Comparisons with other modes of learning,
in terms of the flaws mentioned above, should govern this research. Longitudinal studies are important. All information should be available to all, probably on the Web.

**Full development**

If the research shows that computer-based tutorial learning material can avoid the flaws, we should then proceed to large-scale development of learning material for students of all ages. This will be an extensive worldwide activity, a major project for learning everywhere. We will be putting everyone on the educational moon. It is a glorious prospect, within our grasp.

Probably several segments should be developed in a given area, to allow student choice and to allow comparative testing. Provision needs to be made for continuing development of learning material, as courses will need to be improved and brought up to date, as new information is available.

Experimental studies should continue, many longitudinal, looking at students far after the segment was completed. The aim is both to improve learning and to learn more about the nature of learning. Far more information about learning will be available than has ever been available up to this time. Again, the computer will gather much of the information.

**Final comments**

There are fatal flaws in current Internet learning materials, as expressed here. This does not represent an Internet or World Wide Web problem, but a problem in the types of material designed for the Internet now. We need a new learning paradigm. We can develop with current technology material that is much more effective without the flaws listed, material that is much more sensitive to individual student problems. More experimental work needs to be done to establish this as a fact.

**References**

The following items expand on the ideas presented briefly in this paper.


