

THE UNIVERSITY OF AKRON
Mathematics and Computer Science

Some uses of PDF
in the Educational Sector

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This article discusses some of the many uses of Adobe's PDF (Portable Document Format), with emphasis on the interests of the educator. The topics of document exchange, Web publication, and eBooks are covered. Interactive examples are presented and links to authoring tools are provided.

Table of Contents

1. Introduction

2. Some Uses of PDF

2.1. Document Exchange

2.2. Tutorials on the Web

- Keys to Success
- Resources

2.3. Beyond Hypertext

- Exercises
- Multiple Choice Quizzes
- Objective Questions
- Resources

2.4. Online Examinations

- A Grading Program Demo
- MacQ_TE_X

2.5. Presentations

2.6. Games

2.7. Collaboration

2.8. eBooks

- Resources

3. Concluding Remarks

References

Solutions to Exercises

Solutions to Quizzes

1. Introduction

Several years ago, in 1993, I became interested in writing a calculus tutorial for my students to be posted on the Internet. The design goals of the tutorials included typeset quality on-screen mathematics, cross-referencing using hypertext links, and on-screen color. For mathematics, and more generally, the sciences, using $\text{T}_{\text{E}}\text{X}$ (or $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$) to develop the materials then converting to PDF (Portable Document Format) seemed the ideal solution to meeting the goals.

Since writing the tutorial, known as [e-@calculus](#) [3], I have become interested in exploring the capabilities of $\text{T}_{\text{E}}\text{X}$ and PDF. In addition to providing materials for university students, I've tried to develop tools and techniques to help educators create their own materials for electronic publication. All of my work is available from the [Acro \$\text{T}_{\text{E}}\text{X}\$](#) web site, [1].

In the sections that follow, I will discuss some of the uses for PDF in the area of (mathematical) education, outline some of the tools and resources available that will help you to develop your own scientific materials for the Internet and try to give you a sense of the future of PDF.

2. Some Uses of PDF

The Adobe Acrobat suite of products has a wide range of application in diverse areas: Prepress (PDF has become the industry standard), Business (document exchange, electronic archiving, forms and annotations), Web publication and eBooks.

For those in education, document exchange, Web publication and eBooks are of most interest. The uses of PDF discussed in this section will highlight these three basic areas.

2.1. Document Exchange

People are using PDF more and more mainly for two reasons:

- PDF preserves the layout and design of the document as *determined by the author*;
- PDF is entirely *self-contained*; of greatest importance here is that it contains all the fonts necessary to display the document.

As a result, PDF is becoming a universal document exchange format.

Acrobat 4.0 makes it easy to convert files from the format of the authoring application to PDF. For example, you can simply drag-and-drop a

Microsoft Word file onto Acrobat (formerly known as Exchange), and conversion to PDF is automatic; alternatively, in Acrobat, just open a .doc file and Acrobat will convert to PDF and display it in the viewer. It is this kind of conversion that makes it extremely easy to publish on the Web, or to send a document to a colleague for review by e-mail.

Many people in the scientific community use PDF as a way of distributing their own works—a scientific paper or lecture notes—over the Web. The material is converted from the format of the authoring application to PDF and uploaded to the Internet. Interested individuals who want to review the material using the free Acrobat Reader can be assured that they will see the document as originally designed by the author.

These documents, however, are simply an electronic image of the printed work; they usually contain no color and no interactive elements. In this context, it is really the author's intention that people should download and *print the document* to read it.

PDF, however, is capable of much more than this very straight forward, yet important use.

2.2. Tutorials on the Web

The age of the computer is here! We, in the Education community, must explore ideas and develop techniques for effectively delivering electronic educational materials to students.

The primary mode of delivery of electronic materials to a targeted audience is over the Internet. In the not so distant future, however, paper books (pBooks) will be replaced by electronic books (eBooks) and portable electronic readers. Now is the time for educators to help shape the future of electronic delivery.

In this section, the tutorial is a paradigm for classroom materials of the future. What makes a successful tutorial? What ideas and techniques have been developed that help the student get more involved with the material?

There have been a number of tutorials written and available in PDF covering such areas as mathematics, physics, computer science and macro economics, with others to come I am sure. One of the roles of the [AcroTeX](#) site [1] is to act as a “PDF Library” of educational resources for students.

● Keys to Success

Any publication needs an audience and quality writing¹ to be successful. Additionally, a technical tutorial has to have several attributes to be successful on the Web.

- A good screen design.
- An attractive use of color.
- Use hypertext links for cross-referencing.
- Go ‘[Beyond Hypertext](#)’, [Section 2.3](#).

True electronic materials are meant to be read on-screen, not printed and then read. It is very tiring to read from a computer monitor for long periods of time; therefore, screen design is very important.

For example, to make it easier on the eyes, the viewing region should be kept rather small and the margins should be cropped off; a page should comfortably fit on a computer screen.

This document has a text width of (about) 4 inches and a text height of 3in. By cropping the margins—removing all the unused white space—the

¹Current document excluded.

Acrobat Reader can magnify the page that much more, giving the reader a large-print tutorial.

● Resources

For people who use \LaTeX to author documents, there are a couple of screen design packages available.

- The **web Package**—the one used for this document—provides all the basic needs of someone publishing material on the Web (and meant to be read on-line). The latest version of the package can be obtained from the **web Package** home page, [11].
- If you use `pdftex`, the **pdfscreen Package** has become quite popular in recent years.

One of the easiest ways of obtaining \TeX resources from over the Web is to use the [The \$\TeX\$ Catalogue](#), by Graham Williams, [9]. Both of the above mentioned packages can be found and downloaded there. Use the alphabetical index and go to the **pdfscreen** or **web** packages.

Both packages also hypertext links and color needed for a successful Web document.

Hypertext is introduced through the use of the `hyperref` package, written by Sebastian Rahtz and now maintained by Heiko Oberdiek. `Hyperref` automatically converts standard cross-reference macros to hypertext links and extends their capabilities.

For those interested, I have written a technical article entitled “Using \LaTeX to Create Quality PDF Document for the WWW”, see [10], that discusses such topics as screen design, color, `hyperref` and how to get your \TeX system to create quality output suitable for the Web.

On the [Acro \$\TeX\$](#) site, there is also a slow-paced interactive tutorial on the use of the `hyperref` and `web` packages that I developed for a workshop I gave.

It should be noted that using \TeX is not the only choice for authoring, it is only the best choice.

For topics that do not require exotic symbols or mathematical equations (for example, poetry, history, politics), other authoring applications such as Adobe FrameMaker or Microsoft Word² can be used. Frame and Word

²Both FrameMaker and Word have equation editors that can be used to create mathematics equations; \TeX universally gives better results and is easier and faster to use.

documents can easily be converted to PDF; these applications have the capability of producing cross-reference hypertext links as well.

2.3. Beyond Hypertext

A Web document really needs more than simply hypertext links to cross-reference concepts, it needs user participation to get them involved with the material. In writing [e-@lculus](#), and later another tutorial entitled *Algebra Review in Ten Lessons* [2], I developed several techniques for creating [Exercises](#) (with solutions) and [Multiple Choice Quizzes](#) (with or without solutions, graded or not).

The following paragraphs illustrate by example.

- **Exercises**

The exercise below poses the question, the solution is at the end of the document. Click on the green hypertext link to jump to it.

Exercise 1. Calculate $\frac{d}{dx} \sin^2(x^3)$, and simplify your answer.

Exercises of this type can be part of a tutorial, or the teacher could simply

publish a homework set on the Web (at first, without solutions included, later, with solutions) for the students.

This method of presenting exercises (and examples) has obvious advantages: it saves the limited space on the screen; it allows the student to attempt the problem before seeing the solution; it gives a cleaner presentation of the topic, a presentation not cluttered with solutions to examples and exercises that take away from the main stream of thought.

● Multiple Choice Quizzes

When writing tutorials, “quick quizzes” can be included for the student to take, after a discussion of a topic.

For example, below is a short quiz *with immediate feedback*. The format of the quiz may be of two types, immediate feedback without solution (as in the first question) and with solution (the second question).

Quiz Answer each of the following. Passing is 100%.

1. Was it “In Xanadu did Kubla Kahn a stately pleasure dome decree”³?

³Taken from the poem “Kubla Kahn”, by Samuel Taylor Coleridge.

- (a) True (b) False

2. In what year did Columbus sail the ocean blue?

- (a) 1490 (b) 1491 (c) 1492 (d) 1493

By bringing in Acrobat Form elements and JavaScript, it is possible to create multiple choice quizzes *without immediate feedback*, which are marked and scored.

Instructions: In the quiz below, first click on ‘Begin Quiz’, answer each of the questions (changing your answers is permitted), then click on ‘End Quiz’ to see your score. Click on the ‘Correct’ button to mark the quiz.

Begin Quiz Using the discriminant, $b^2 - 4ac$, respond to each of the following questions. Passing is 100%.

1. Is the quadratic polynomial $x^2 - 4x + 3$ irreducible?

Yes

No

2. Is the quadratic polynomial $2x^2 - 4x + 3$ irreducible?

Yes

No

3. How many solutions does the equation $2x^2 - 3x - 2 = 0$ have?

none

one

two

End Quiz

► Evaluation of the quizzes is done on the *client-side*, that is, within the browser or Reader. The document is completely self-contained; there is no CGI scripting involved. One of the great advantages here is that the document can be downloaded, brought into the Acrobat Reader and reviewed off-line. (The performance of the document is much better within the Acrobat Reader than within a Web browser.)

● Objective Questions

I have recently been working on the problem of evaluating objective-type questions on the *client-side*. Effort in this area was inspired by the work of Drs. Wlodzimierz Bryc and Stephan Pelikan of The University of Cincinnati. These two have developed an html based **Online Exercise System** [7] which can evaluate objective type questions. This evaluation, however, takes

place on the *server-side*; the student must be connected to the server to get an evaluation of the work.

There are certain kinds of questions in mathematics and related fields, that the teacher would like more than a multiple choice guess from the student. For example, suppose the following question is posed:

Question: $\frac{d}{dx} \sin^2(x) =$

The student would be expected to enter a valid mathematical expression that represents his/her answer. One such is $2 * \sin(x) * \cos(x)$. Another valid response is $\sin(2 * x)$.

Objective questions increase the level of difficulty for the student. Not only must they successfully solve the problem, they must enter the answer in the correct syntax. No multiple guessing for this kind of question.

The answer to the above question is not as difficult to evaluate as you might expect. First, check for syntax errors, then evaluate the student's response at three or four randomly selected numbers in the domain of the correct answer. If there is no significant difference between the evaluation of the student's expression and the evaluation of the correct expression, the student's response is classified as correct.

It should be noted that the **Acrobat Reader** has a powerful JavaScript engine built into it that is used to carry out the above plan. JavaScript is used to check for syntax errors (mismatched parentheses and unrecognized functions) and to evaluate the expressions numerically.

A more elaborate demonstration document is available from the **JQuiz** [5] page of the **AcroTeX** web site. Contained in that document is a discussion of the correct syntax for entering the answers, as well as additional questions.

- **Resources**

The process for creating online exercises and quizzes as demonstrated in this section has been automated in the **L^AT_EX** package **Exerquiz**, a companion to the **Web** package. **Exerquiz** is available at the **Web and Exerquiz Home page**, [11].

2.4. Online Examinations

At some institutions there is great interest in electronic testing of large class sections. As mentioned before, Bryc and Pelikan [7] have developed an `html` solution; but what about PDF?

First, why PDF? The answer is textbook quality typesetting. A document marked up in $\text{T}_{\text{E}}\text{X}(\text{L}\text{A}\text{T}_{\text{E}}\text{X})$ and converted to PDF has a typeset quality to it; the look of it is very pleasing to the eye.

- **A Grading Program Demo**

My work in this area is rather preliminary. I have developed a grading program (CGI script)—using Adobe’s FDF Toolkit⁴—that processes test data submitted from a PDF document. A calculus quiz⁵ (in PDF) is available that illustrates the functionality of this grading program: a user enters a multiple choice response to each question; the responses of the user are then submitted and processed; a marked quiz, in the form of a second PDF file, is returned with the user’s score and a complete set of solutions.

- **Mac $\text{Q}_{\text{T}}\text{E}_{\text{X}}$**

Dr. Ross Moore, Department of Mathematics, Macquarie University, has developed a testing system called [Mac \$\text{Q}_{\text{T}}\text{E}_{\text{X}}\$](#) [6] that uses PDF. Currently,

⁴<http://partners.adobe.com/asn/developer/acrosdk/forms.html>

⁵Grading Demo: http://www.math.uakron.edu/~dpstory/demo/quiz1_q.pdf

there are three static quizzes.

Dr. Moore's system, which uses the **Exerquiz Package** [11], delivers the questions and solutions to the student in one file. The solutions are *hidden* until the student submits his/her responses, at which point, the quiz is completely marked, using the JavaScripts defined in **Exerquiz**, and the solutions are revealed for the student to review.

Future plans are to introduce some randomness into the test construction. Frances Griffin, one of Dr. Ross' students, is working on the problem of generating random variations on problem types using **Mathematica**, these questions and solutions will then TEX ed and served up in response to a request for a quiz.

2.5. Presentations

In the scientific community, developing a presentation, whether it be for a professional talk or for the classroom, is always a problem. How can one get (Microsoft) **Powerpoint**-type presentations when the material involves a lot of specialized symbols and math equations? Of course, $\text{T}\text{E}\text{X}/\text{\LaTeX}$ can handle the symbols and the equations, but what about the line-by-line

presentation of topics?

In recent years, a few \LaTeX (slide development) packages and supporting utilities have been developed to help create scientific presentations. The slides are prepared in \LaTeX , then converted to PDF. PDF has a number of “transitions effects” that can be used to give a snappy, professional-looking presentation.

My web page [PDF Classroom Demonstration](#) [8], which only contains a couple classroom presentations that I have given, has a list of packages and utilities that are used to prepare slides using \LaTeX and PDF.

2.6. Games

Games stimulate interest in mathematics, promote creativity and provide a resource of class projects⁶. Simple games can be created using \LaTeX and PDF that are inexpensive to build and challenging, educational and informative to play.

I have created several games, available at the [AcroTeX](#) site, [1]. The

⁶In an undergraduate course on Theoretical Statistics, I asked the students to make up their own set of questions to a Jeopardy game. I had never seen such enthusiasm!

games show off the richness of PDF. It's *form annotations* can be cleverly exploited to obtain a variety of interesting effects.

Many people have asked me, "How do you do that?" In partial response to that question, I have recently published a \LaTeX macro package, the `JJ_Game` class [4], that will help educators create their own Jeopardy-like game in a very simple and automated way.

2.7. Collaboration

One of the under-utilized features of the Acrobat suite of applications is its ability to *export annotations*.

Suppose you and a subset of your colleagues are preparing a joint publication or a grant proposal⁷. One person is assigned the task of writing the document. A preliminary document is prepared and needs to be reviewed by all the members of the team. How can PDF help here?

Convert the document to PDF, and distribute it to each member of the team

⁷Some granting institutions now accept proposals in PDF; the NSF (National Science Foundation), for example. See, <http://www.nsf.gov/pubs/2000/iin126/iin126.htm> and <https://www.fastlane.nsf.gov/a1/pdfcreat.htm>.

for review. (The document can be encrypted and sent by e-mail, or uploaded to a web site for download. Only people with the security password can open the file.) If each member of the team has the **Acrobat** application (formerly known as **Exchange**), they can *annotate* the document: attach sticky notes, sound and other files; highlight, cross-out, and underline passages.

Now, how to get all the annotations back to the one doing the writing so the document can be revised?

A bad solution would be for each member of the team to return the annotated PDF file, the writer would then have a large number of the same document to sift through, find all annotations, and use them to revise the master document.

The best solution is as follows:

- Have each member of the team save their annotations to a separate file. In **Acrobat**, with the document open, choose 'File > Export > Annotations' from the menu system. Each member of the team can save the annotation under their own name and revision number, smitheRev2.fdf. This FDF file (Forms Data Format) contains only the annotations.

- Have each member of the team e-mail the FDF file to the writer.
- The writer can then *import* each of the FDF files into his/her own copy of the PDF document. To do this, in **Acrobat**, choose ‘File > Import > Annotations’. The annotations as each team member wrote and placed them, are now in the writer’s copy in exactly the same location.

In this way, all the annotations appear in one document together. This makes it much easier for the writer to modify the original document, taking all comments into account.

This cycle can be repeated as many times as revisions are needed.

2.8. eBooks

Web publishing gives the educator the ability to provide students with up-to-date information in rapidly changing areas of study. The eBook is a way the educator start collecting royalties for his/her work.

Adobe has developed a variety of technologies to support the eBook industry: CoolType (a font-rendering technology that dramatically improves on-screen text resolution); PDF Merchant (enabling the secure exchange of content electronically— from sensitive corporate data to eBooks); Web Buy

(a technology that lets you download encrypted files from the Web and unlock them to read on your personal computer or reading device, fully integrated with Adobe Acrobat and Acrobat Reader). Adobe plans to make PDF the industry standard in the electronic publishing world⁸.

Companies are using these technologies to provide a service to authors who would like to publish. The mightywords⁹ company, for example, provides hosting, advertisement, accounting, and payment of royalty services. Information about how to get started, royalty payments and hosting fees can be found at the “Publish eMatter”¹⁰ page.

One major problem for those in the educational sector is that an eBook, as “published” by mightywords, is *not peer reviewed*, hence, does not carry nearly the weight of a traditional publication¹¹.

Textbook publishers will soon realize the importance of the eBook in the classroom. Electronic publishing is, by definition, paperless; the cost of

⁸There is a major competitor, Microsoft Corporation with Microsoft Reader 1.5 with ClearType™, see <http://www.microsoft.com/reader/default.htm>

⁹<http://www.mightywords.com/>

¹⁰http://ematter.fatbrain.com/ematter/support/publishing_details.asp

¹¹In fact, an eBook carries *no* weight in the halls of academia.

producing a book electronically is much less than that of producing the book on paper. Corrections can be made using electronic sticky notes (available with the PDF format), peer review can be done electronically the same way. The production, distribution and storage costs all are substantially less for the electronic book than for the paper book.

One of the great advantages of a “pBook”, other than tradition, is that it *exists*: it has weight and substance, you can feel it, you can hold it. A book is portable; you can take it anywhere, even to the classroom!. You can adjust your body position to read it. You can mark on it, just as Pierre de Fermat did when he wrote his famous marginal note¹². There is something in the touch and feel of a good book; a book can be like an old friend, familiar, always there when you need it.

I don't believe the eBook can completely replace a paper publication, but it will play a major role in the future of publishing. With the proliferation of electronic readers¹³, the eBook now has most of the desirable properties

¹²“I have discovered a truly remarkable proof which this margin is too small to contain.”

¹³For a discussion of current electronic readers, go to eBooks N'Bytes at http://www.ebooksnbytes.com/ebook_readers.html

of a book: it has weight (at least the reader does); it is portable—you're not tied down to a computer desk—, take it to class; you can mark up the text with notes and highlight important passages necessary for success on the next test. Could an eBook (and reader) be like an old friend? It will take time before the answer to that question is known.

● Resources

The [Digital Worm](http://www.digitalworm.com/), <http://www.digitalworm.com/>, is a web site that contains all the news from the eBook world, both hardware and software.

3. Concluding Remarks

The portable document format is a self-contained, platform-independent file format. The Acrobat software can be used, not only to create PDF, but to add a rich array of form elements, which when, combined with the powerful Acrobat JavaScript functionality, can provide the user an interactive, dynamic document. For the educator, these capabilities can be exploited to enhance the learning experience of student.

I hope this article has provided some basic information about the uses of

PDF, given you some ideas about the possibilities, and surprised you as to its capabilities.

References

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Solutions to Exercises

Exercise 1.

$$\frac{d}{dx} \sin^2(x^3) = 2 \sin(x^3) \frac{d}{dx} \sin(x^3) \quad \text{Power Rule}$$

$$= 2 \sin(x^3) \cos(x^3) \frac{dx^3}{dx} \quad \text{Cosine Rule}$$

$$= 2 \sin(x^3) \cos(x^3) (3x^2) \quad \text{Power Rule}$$

$$= 6x^2 \sin(x^3) \cos(x^3) \quad \text{Algebraic simplification}$$

$$= 3x^2 \sin(2x^3) \quad \text{Double Angle Identity}$$

Thus,

$$\frac{d}{dx} \sin^2(x^3) = 3x^2 \sin(2x^3)$$

Exercise 1

Solutions to Quizzes

Solution to Quiz:

In 1492,
Columbus sailed the ocean blue
Profound was the logic in his quest,
to get to the east, he headed west.¹⁴

End Quiz

¹⁴This poem was obtained by personal communication from Leonard A. Stefanski, Department of Statistics, North Carolina State University.