HOW PROGRAMMERS LEARN NEW SKILLS

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Abstract

The rate of change of software technology is extremely rapid. New programming languages appear almost monthly. New programming tools appear almost daily. The fast rate of software technology change means that software professionals are faced with a continuing need to learn new skills. What channels are available to software professionals for learning new skills? How good are the available ways of learning, and what new ways are likely to occur?

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Introduction

The world of computing and software is evolving new technologies as rapidly as any industry in human history. This means that software professionals are faced with a need to acquire new knowledge and new skills at a very rapid clip.

As of 2000 the United States currently employs about 2,100,000 personnel in the technical areas of programming or software development and maintenance, about 235,000 software managers, and perhaps another 700,000 ancilliary personnel in related specialities such as software sales, customer support, software technical writing, and many others. The U.S. total is amore than 3,000,000 professionals in the overall software domain. The European total is slightly larger that the United States, and the world total is approaching 15,000,000. All of these software personnel need constant refreshment to stay current.

There are currently 10 major "channels" for software personnel to acquire new information. These channels vary in effectiveness and costs:

  1) In-house education
  2) Commercial education
  3) Vendor education
  4) University education
  5) Self-study from work books
  6) Self-study from CD-ROMs
  7) Conferences
  8) On-line education via the Internet and World Wide Web
  9) Books
10) Journals

A sampling of current terms, acronyms, and abbreviations that have come into prominence within the software community over the past few years gives a flavor to the kinds of technologies that software personnel need to know about in 2000 that in some cases did not exist even in 1985:

ASP (application service provider – software available via the World Wide Web)
B2B (Acronym for "business to business" or business via the World Wide Web)
BPR (business process reengineering)
CASE (computer aided software engineering)
Client-server computing
CMM (capability maturity model)
Configuration control
Data quality

Data warehouses

Dot Com (a company doing business via the World Wide Web)

e-business (Short for "electronic business" or doing business on the World Wide Web)

ERP (Enterprise Resource Planning – applications supporting many corporate functions)

Function point metrics

GUI (Graphical user interface)

HTML (hypertext markup language)

I-CASE (integrated computer aided software engineering)

IE (information engineering)

ISO (International Standards Organization)

ISP (internet service provider)

JAD (joint application design)

OO (object-oriented)

OLAP (on-line analytical processing)

OLE (object linking and embedding)

QFD (quality function deployment)

Process improvement

RAD (rapid application development)

Reusability

TQM (total quality management)

UML (unifed modeling language)

Each of the topics in this list is relatively new. Each is relatively complicated. How can software personnel stay current with the latest technologies? Even more important, how can software personnel actually learn how to use these new concepts well enough to be effective in their jobs?

A way of evaluating the overall effectiveness of various education channels is to combine data on the numbers of students using the channel, the student's satisfaction with the materials, and the student's abilities to actually acquire new skills.

The rankings in this article are derived from interviews and benchmark studies which the author's company performs.

The major software employers typically try to keep their employees up to speed by offering training and education on a continuing basis. The best in class software employers typically have a pattern that resembles the following:

- From 4 to 10 weeks of intensive training for new technical employees.
- Annual in-house training that runs from 5 to 10 days per year for technical employees.
- Annual training that runs from 1 to 10 days per year for software managers.
- From 1 to 3 external, commercial seminars per year for managers.
- At least 1 external seminar per year for technical staff members.

- Funding for between 1 and 3 external conferences per year for technical employees.
- Tuition refund programs for technical courses at the university level.
- Access to the World-Wide Web.

Because multiple channels of education are available, it is interesting to consider the topics for which each kind of channel is likely to be selected and their strengths and weaknesses.

In-House Education

In-house education was number one in overall effectiveness from 1985 when our surveys started through 1999. However, this channel is only available for employees of fairly large corporations. SPR estimates that roughly half of the U.S. software personnel currently work in organizations large enough to have in-house training; i.e just over 1,000,000 U.S. software professionals have access to this channel.

The large software employers such as Andersen, AT&T, EDS, IBM, Microsoft, and many others have in-house curricula for software professionals and managers that are far more complete and current than any university in the United States. A former chairman of ITT observed that the Fortune 500 companies in the United States have more software instructors than all universities put together. Employees within large companies have more student days of in-house training than all other channels combined.

The in-house courses within major corporations are usually very concentrated and very intensive. An "average" course would run from two to three business days, starting at about 8:30 in the morning and finishing at about 4:30 in the afternoon. However, to optimize student availability, some courses continue on into the evening.

From observations of the curricula and attendance at some of the courses, the in-house education facilities of large corporations are among the most effective ways of learning current technologies.

Another advantage of in-house training is the ease of getting approval to take the courses. It requires far less paperwork to gain approval for a corporation's in-house training than it does to deal with a tuition refund program for university courses.

Commercial Education

Commercial education ranked number two in overall effectiveness. There is a thriving and fast-growing subindustry of commercial education providers for the software domain. Companies within this subindustry include Data-Tech, Digital Consulting Inc. (DCI), Delphi, FasTrak, the Quality Assurance Institute (QAI), The Learning Tree, Technology Transfer Institute (TTI), and many others who teach on a national or even international level.

There are also hundreds of local companies and thousands of individual consultants who teach courses on a contract basis within companies and sometimes as public courses as well. There are also courses offered by non-profit organizations such as the ACM, DPMA, IEEE, IFPUG, SEI, and many others.

SPR estimates that about 350,000 U.S. software personnel take at least one commercial software seminar in the course of a normal business year.

Since the major commercial educators run their training as a business, they have to be pretty good to survive. A primary selling point of the larger commercial education companies is to use famous people as instructors on key topics. For example, such well-known industry figures as Chris Date, Tom DeMarco, Ed Yourdon, Dr. Gerry Weinberg, Dr. James Martin, and Dr. Carma McClure all offer seminars through commercial education companies.

A typical commercial seminar will run for two days, cost about $895 to enroll, and attract 50 students. A minor but popular aspect of commercial education is the selection of very good physical facilities. Many commercial software courses are taught at resort hotels in areas such as Aspen, Orlando, Phoenix, or San Francisco.

The main strengths of the commercial education world are twofold:

1) Very current topics are the most salable.
2) Top-notch instructors are the most salable.

This means that commercial seminars are likely to cover material that is not available from a university or even from an in-house curriculum. It also means that students get a chance to interact with some of the leading thinkers of the software domain.

Vendor Education

Vendor education ranked number three in overall effectiveness. Vendor supplied education has been a staple of the software world for almost 50 years. Because vendor education in tools such as spreadsheets and word-processors are taken by non-software personnel, the total numbers of students is enormous. However, within the software domain SPR estimates that about 500,000 software personnel will take at least one vendor course in a normal business year.

Vendor education used to be free in the days when hardware and software were still bundled together. Some vendor education is still free today, when used as part of marketing programs. Normally vendor education is sold to clients at the same time that they buy the tools or packages for which training is needed.

Almost every large commercial software application is complicated. Even basic applications such as word processors and spreadsheets now have so many features that they are not easily mastered.

The size, feature set, and complexity of software products means that every major vendor now has some kind of education offering available. For really poopular tools in the class of Microsoft Word, Word Perfect, Excel, Artemis Views, KnowledgePlan, etc. there may be local consultants and even high-schools and college courses that supplement vendor-supplied education.

Vendor-provided runs the gamut from very good to very poor, but on the whole does a creditable job of getting clients up and running on the applications in question.

Vendor education is usually a lot cheaper than commercial education, and the effective costs are sometimes less than $100 per student day. Vendor education is often offered on company's own premises, so it is generally very convenient. On the other hand, you don't expect big name instructors to constitute the faculty of vendor training either.

As software packages continue to evolve new features and more complexity, vendor-supplied education will remain a stable feature of the software world well into the next century.

University Education

University education is only number four in overall effectiveness for software professionals. Universities are often not very current in the topics that they teach. In general, university curricula lag the actual state of the art of software by between five years and 10 years. This lag is because of the way universities develop their teaching materials and their curricula.

There are some exceptions to this rule. Many universities have established fairly close ties with the local business community, and attempt to offer courses that match the needs of the area's software employers. For example, Stevens Institute of Technology in New Jersey has established close ties with AT&T and is offering a master's program that includes topics suggested by AT&T. Bentley College in the Boston area, Washington University in St. Louis, Georgia State University in Atlanta, St. Thomas University in the St. Paul area and many other schools adjacent to large software producers have adopted similar policies of curricula based on the needs of major software employers.

SPR estimates that perhaps 95,000 U.S. software professionals will take university or college courses in the course of a normal business year.

Having just completed a consulting study on continuing software education, a few practical issues were noted. The way companies fund tuition refund programs is often remarkably cumbersome. Sometimes several layers of management approval is required. The courses

themselves must be job-related within fairly narrow boundaries. Some companies reserve the option of having the students withdraw "because of the needs of the company."

Also, the tuition refund policies are based on achieving passing grades. This is not an unreasonable policy, but it does raise the mathematical probability that the student will end up with out of pocket expenses which can be significant.

On the whole, university training appears to be more expensive and less effective than in-house training, commercial education, or vendor education for practicing software professionals.

Conferences

Software-related conferences ranked number five in effectiveness in teaching new skills. However, the would rank number one in highlighting interesting technologies.

There are now major software conferences every month of the year, and some months may have multiple events. Conferences are sponsored both by non-profit organizations, such as the Air Force STSC, IEEE, IFPUG, GUIDE, SHARE, or ASQC and also by commercial conference companies such as Digital Consulting Inc. (DCI), Software Productivity Group (SPG), or Technology Transfer Institute (TTI).

In addition, there are vendor-hosted conferences for users by companies such as Microsoft, Computer Associates, Oracle, CADRE, COGNOS, SAS and the like. These are often annual events that sometimes draw several thousand participants.

SPR estimates that about 250,000 U.S. software professionals will attend at least one conference in the course of a normal business year, and some professionals may attend multiple conferences.

Software conferences are where the cutting edge of software technologies are explained and sometimes revealed for the very first time.

Many conferences also feature training seminars before or after the main event, and hence overlap commercial education channels and vendor education channels.

However, most of us go to conferences to find out what is new and exciting in our chosen domains. The mix of speakers and topics at conferences range from brilliant to boring. Conferences are arranged with many concurrent sessions so that it is easy to leave a boring session and find a better one.

Most conferences interleave keynote speeches to the whole audience with parallel sessions that cover more specialized topics. A typical U.S. software conference will run for three days, attract from 200 to more than 3000 attendees, and feature from 20 to more than 75 speakers.

On the whole conferences do a good job in their primary role of exposing leading-edge technologies to the audience. You seldom come away from a conference with an in-depth working knowledge of a new technology. But you often come away with a solid understanding of what technologies merit closer analysis.

Within recent years, several conferences have become so large that the proceedings are now starting to be released on CD ROM rather than traditional notebooks or bound hard copies.

Self study Using Workbooks

The self-study market ranked number six in overall effectiveness. The market for traditional self-study courses is not fast growing, but has been relatively solid and stable for 50 years. SPR estimates that a total of about 50,000 software professionals will take some kind of self-study course over a normal business year.

The usual format of self-study material is a loose-leaf notebook. This form of self-study material can be effective for those who are self-motivated, but tends to be bland and frequently boring. Some self-study courses also include video or audio cassettes.

The most common topics for self-study are those that have relatively large market potentials. This means that basic subjects such as "Introduction to COBOL Programming" are most likely to be found in self-study form.

Really new technologies are seldom found as self-study courses, because of the time required to produce the materials and the uncertainty of the market. There are always exceptions to rules, and fairly new topics such as ISO 9000-9004 standards have already arrived in self-study form due to the obviously large market.

Self Study Using CD-ROM's

The technology of self-study courses is on the verge of being transformed by CD-ROM and DVD approaches. The older form of self-study courses consisted of tutorial materials, exercises, and quizzes often assembled into loose-leaf notebooks. The CD-ROM or DVD varieties include all of the prior approaches, but can also feature hyper-text links and a huge variety of supplemental information.

The prospect of fully interactive learning via CD-ROM is an exciting one, since graphics, animation, voices, and other topics can now be included. However, the costs and skill required to put together an effective CD-ROM course are significantly greater than those needed for traditional workbooks.

Until about 1995, the number of CD-ROM drives in the hands of potential students was below critical mass levels, and many of these were older single-speed drives with sluggish access times and jerky animation.

However, by 1999 SPR estimates that more than 85% of software perrsonnel have CD ROM or DVD drives on their office computers. Ownership of home computers is also very high among software professionals (perhaps 90%) and CD ROM's or DVD drives for home computers are now almost universal. Indeed writable CD drives are now becoming standard features on new computers.

As of 2000, SPR estimates that more than 50,000 software personnel have taken self-study courses via CD ROM's or DVD. There are probably less than 75 such courses currently available due to the difficulty and costs of production.

As the 21st century advances, it is possible that self-study courses using CD-ROM approaches will expand in numbers and improve in effectiveness. What would really give this self-study channel a boost would be light weight portable CD-ROM or DVD viewers that can be carried and used on airplanes. This technology already exists, but is still expensive and of limited utility. The same is true of electronic books. (The fact that airlines want to sell in-flight entertainment and are playing with the idea of prohibiting in-flight usage of CD players is also a troubling factor.)

On-line Education Via the World Wide Web

It is premature to actually rank the effectiveness of on-line education via the World Wide Web. Since about 1995 usage of the Web has exploded across the software and business world. Education is now beginning to show up on the Web, and can be expected to grow dramatically within a few years.

The explosive growth of internet service providers (ISPs) and expanding capabilities of older on-line services such as America On Line and CompuServe are openin up a powerful new channel for learning software-related skills.

SPR estimates that about 90% of the U.S. software professional personnel now use the Internet, Web, or one of the other on-line channels. However, surfing the Web is not the same as learning a new skill or taking a course. Here SPR estimates that less than 25,000 U.S. software personnel have used on-line education as of 2000.

There are already a growing number of special-interest groups and forums on various software topics, such as usage of function point metrics, quality assurance, standards, and the like. As a research tool for exploring potential topics of interest, the on-line services are now the most effective of any known method. Gartner Group, for example, is now offering a new on-line reference service to complement their traditional subscription service.

The prospect of using the Web and on-line services for formal courses is beginning to occur, but not enough solid data exists to evaluate the effectiveness. There is reason to believe that on-line training may be quite effective, but how broad and deep this channel will become is still speculative.

Within 10 years, it would not be surprising to see Web-based training climbing up to the first position in terms of overall effectiveness and number of students using the channel. The Web may well transform eduction, just as it is transforming business operations and research.

Professional Books

Software books tend to rank eighth in overall effectiveness in transferring software skills in the United States. The U.S. software industry does not appear to be especially literate, which is something of a surprise given the nature of the work. Also, the software book publishers as a class are often inept when it comes to marketing there wares.

As of 2000 there are more than 3,000,000 software personnel in the United States and the numbers are growing fairly rapidly. Yet software book publishers regard sales of more than 10,000 copies as a fairly good volume. Sales of 25,000 copies are remarkably good for software titles.

Very few software-related books sell in the range of 1,000,000 copies, and the ones that do aim at the end-user market and not the professional market. For example books on Visual Basic or primers on Windows can exceed 1,000,000 copies in sales because there are about 10,000,000 users of these products who are not professional software personnel.

It is possible to learn a variety of software-related skills from books, but this approach is not as widely utilized as seminars or some kind of formal training.

There are many excellent software books on the market by publishers such as Addison Wesley, Dorset House, IEEE Computer Society Press, McGraw Hill, Prentice Hall, Que, Microsoft Press, Thomson International, and the like.

Also included under the heading of books would be monographs published by various companies and associations. For example, software-related monographs of 50 to more than 100 pages in size are published by Andersen Consulting, Auerbach, IBM, IFPUG, IEEE Press, McKinsey, Gartner Group, Meta Group, the Software Engineering Institute (SEI), and Software Productivity Research (SPR).

These privately published monographs are distributed primarily to the clients of the publishing organization. The costs range from zero up to more than $25,000 based on whether the

monograph is intended as a marketing tool, or contains proprietary or special data of interest to the clients.

There are many software bookstores and large software sections within general bookstores such as Borders. And of course software books are featured in all of the major Web-based book stores such as Amazon and Barnes and Noble. The total volume of good books on software topics probably exceeds 1,500 titles for technical books and 100 titles for management books.

Yet in spite of the plentiful availability of titles, many software managers and quite a few technical software personnel don't read more than one or two technical books a year, based on responses to assessment interviews.

SPR estimates that software professionals purchase about four books per year on average (more than seem to be read). In any case, it would be hard to keep current just from books since software technology changes are so volatile.

There is a curious omission in the book domain for software and project management topics. Among the more mature professions such as medicine and law, a significant number of books are available in audio form such as cassettes or CD's so they can be listened to at home or in automobiles. We have not yet encountered any audio titles in the sofware engineering or project management fields.

As the 21st century begins, an increasing number of technical books are becoming available on-line and can be viewed on personal computer screens or downloaded. This method of gaining access to books is expanding, but has not yet reached a critical mass. The author estimates that less than 25 software titles are available in on-line form, and that less than 10,000 software professional have utilized this channel of gaining access to books. However, both the number of titles and accesses should increase rapidly over the next 10 years.

Software Journals

Software journals tend to rank tenth in transferring skills. The main strength of software journals is in popularizing concepts and presenting the surfaces of technologies rather than the depths of technologies.

There are hundreds of software-related journals. Some are commercial journals published for profit and depending upon advertizing revenues. Many others are produced by non-profit professional associations. For example this journal, IEEE Computer, is produced by a non-profit association as are the other IEEE journals.

A literate and very broad-based software journal is published by the U.S. Air Force' Software Technology Support Center. This journal, Crosstalk, has become one of the few software

journals to strive for depth in articles, rather than shallow coverage consisting primarily of short quotes from industry fitures.

There are so many journals that a number of them are quite specialized and occupy fairly narrow niches. Examples of some of these specialized niche journals include Metric Views (the journal of the International Function Point Users Group) and Cross Talk (the journal of the Air Force Software Technology Support Center).

Many software journals are available to software professionals for free, providing the potential subscribers bother to fill out a questionnaire (and have some responsibility for acquiring tools or software). On the other hand, some journals have annual subscriptions that can exceed $1000.

The software professional world ends up with subscriptions to quite a few journals, even though few may actually be read. SPR estimates that software technical personnel subscribe to or have access to about four journals per month on average.

Comparatively few software journals contain articles of lasting technical value. When journals do discuss technologies, it is seldom an in-depth treatment. This is understandable, given that neither journalists nor professional contributors can spare more than a minimum amount of time to assemble information before writing articles.

The best articles in terms of technology transfer are those on specific topics, often in special issues. For example, several journals have had special issues on topics such as quality assurance, measurement and metrics, software maintenance, object-oriented approaches, change management, and the like.

The least effective articles are the typical broad-brush surveys produced by journalists that consist largely of short quotes from 20 to 50 different people. This approach can seldom do more than bring a topic into public view.

Summary and Conclusions

In any technical field it is hard to keep up with the latest developments. Software technologies are changing very rapidly as the 21st century advances, and this makes it difficult to stay current.

Ten different channels are available to the software community for acquiring information on new software technologies. The most effective historica channel is in-house training within a major corporation, but that channel is only available to the corporation's employees.

Of the other channels, two appear to have strong potential for the future: Self-study utilizing CD-ROM or DVD technology, and on-line study using the World Wide Web or an information utility such as the Internet, CompuServe, America On-Line or one of the others. Both of these channels are beginning to expand rapidly in terms of information content and numbers of users.

As the Internet and on-line services grow in usage, entirely new methods of education may be created as a byproduct of large-scale international communication channels.