Resources to support computer programming learning and computer science problem solving

Article · January 2010

DOI: 10.1145/1936755.1936766

2 authors:

Robert Pierce
IBM
40 PUBLICATIONS **74** CITATIONS
SEE PROFILE

Manuela Aparicio
Universidade NOVA de Lisboa
117 PUBLICATIONS **915** CITATIONS
SEE PROFILE

Resources to Support Computer Programming Learning and Computer Science Problem Solving

Robert Pierce
Alfred, Maine
USA
robertp@us.ibm.com

Manuela Aparício
Adetti/ISCTE
Portugal
manuela.aparicio@iscte.pt

ABSTRACT

In this paper we analyze the use and the preference of several types of resources either to improve knowledge of software programming and programming language or to solve specific problems by using those languages. Answers to these questions may be especially important either to teachers or to writers of technical communication. Collaborative tools may also be part of the solution to meet student information needs.

Categories and Subject Descriptors

K.3.2 [**COMPUTER AND EDUCATION**]: Computer and Information Science Education - *Computer science education*

General Terms

Documentation, Languages

Keywords

Manuals, Information Sources, Teaching Programming Languages

1. INTRODUCTION

Information is pervasive; information is "all around us." Although this statement is referred by an enormous number of people, it is still important to know and understand which sources are the most popular information resources. In this paper we analyze the preferred information resources used by students in a specific context. By the term "information resource" we mean content that must be expansible, understandable, substitutable, transportable, distributable, and sharable [12].

In a period where Web 2.0 is mixing many different forms of communication it is important to analyze what are the most commonly and frequently used forms of communication. Information resources can be an important part of a person seeking knowledge, experience, and gaining insight for behavioral adaptation. From a biological point perspective, humans seeking information is regarded as an indispensable skill for surviving in the environment [1].

Choo [14] and Kuhlthau [15] classify information sources into internal personal, internal impersonal, external personal, and external impersonal. Seekers evaluate personal and impersonal sources with different sets of criteria [16].

With the development of e-learning, while students still have the option of access to traditional classes in class rooms or using e-learning training. However, choosing other learning resources to solve development problems may be more commonly used. Alternative learning resources include: Colleagues, Online documentation and Printed manuals (or books)

Other sources include forums, product help, or other forms of online user assistance. All of these sources of information may be classified according to their purpose.

Several needs for seeking information, including learning, are identified by several researchers. [9] Task problem solving is one of the most common information needs being studied. [17] [18] [19]

In this paper, our main concern is identifying what information resources students prefer and what information resources they generally use. Our analysis is based on two different contexts:

- In a context where students need to improve knowledge about computer programming.
- In a context where students need to solve a specific problem using a certain programming language.

In the following sections, some of the problems of programming languages are analyzed. Then, we identify the main sources of information studied by researchers, the empirical work that has been done, and some of the main results of it.

2. LEARNING PROGRAMMING LANGUAGES

Teaching a programming language is a challenging issue, already with a long history [10]. Typically, the discussion is focused in programming language. [7] While some researchers advocate the adoption of some programming languages (like Java, Prolog or C++) [6], others identify limitations of widely used languages (like Pascal) [3].

But practitioners and researchers also analyze the creation of new environments. The employment of those new platforms goes beyond the traditional e-learning. [8][13].

The teaching of the history of programming languages is also presented as an additional subject to teach programming languages. [4]

OSDOC'10, November 8, 2010, Lisbon, Portugal.

3. SEEKING INFORMATION

To help illustrate the problems involved in the search of information, we include an example of a person looking for Java programming information by searching for it from the Web, and showing the results a user gets.

In the following example we use a Web browser and the Google search utility to search for Java programming information.

In this example, we pretend to be a student seeking information to learn how to write code that works in components with a J2EE dependency.

We start by search on "java programming j2ee," and get these results:

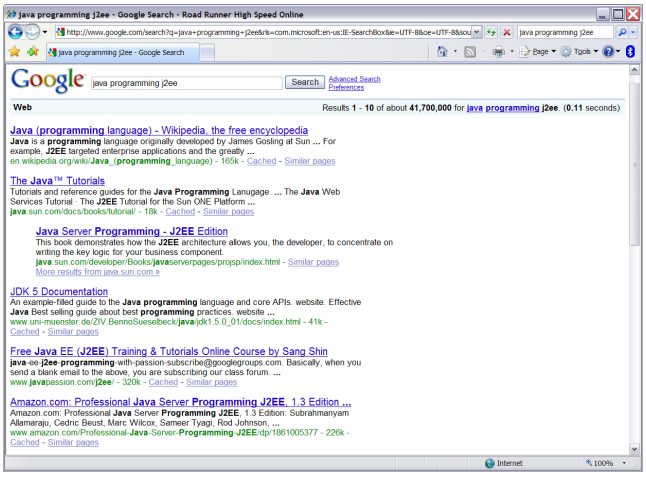

Figure 1 – Search on "java programming j2ee,"

Of the first ten links in the search results almost all of the learning resource types that were included in our survey are present.
Many of the links themselves illustrate the learning resource type:

- http://en.wikipedia.org/wiki/Java_(programming_language) (Wide array of contextual information and links to more information and learning resources)
- http://java.sun.com/docs/books/tutorial/ (Wide array of online help learning resources)
- http://java.sun.com/developer/Books/javaserverpages/projsp/index.html (Book to purchase)
- http://www.javapassion.com/j2ee/ (Lists both online and onsite training courses)
- http://www.amazon.com/Professional-Java-Server-Programming-J2EE/dp/1861005377 (Book to purchase)
- http://www.apl.jhu.edu/~hall/java/ (Programming Resources)
- http://www.apl.jhu.edu/~hall/java/FAQs-and-Tutorials.html (Forums)
- http://www.programmingtutorials.com/
- http://forward.com.au/javaProgramming/index.html
- http://www.icesoft.com/products/icepdf.html (Advanced programming resources)

In this example it becomes apparent that dynamic online help is the most useful and pervasive form of communication for knowledge and learning.
The search aggregates multiple types of information and while the search returns links to information in a possibly not most optimal or useful order, users can quickly review the content and content type to distinguish what to review in more detail or not.
In this example, from the first link, scrolling to the additional information and then clicking one of those links, got us to useful information:
http://java.sun.com/
and from there to here:
In particular, this site is useful as a point of entry to java programming:
http://java.sun.com/new2java/

Figure 2 – possible point of entry to java programming

This Web site offers introductory and overview information, Getting Started information that provides advice and suggested paths for how best to begin learning, tutorials, code examples, and reference topics.

It is not clear if the need for seeking information available on other Web sites, in books, training, or other publications is necessary or even recommended.

To compare these results with what is available for other, perhaps less widely used programming languages, we search on "c++ programming." In this example we get these results:

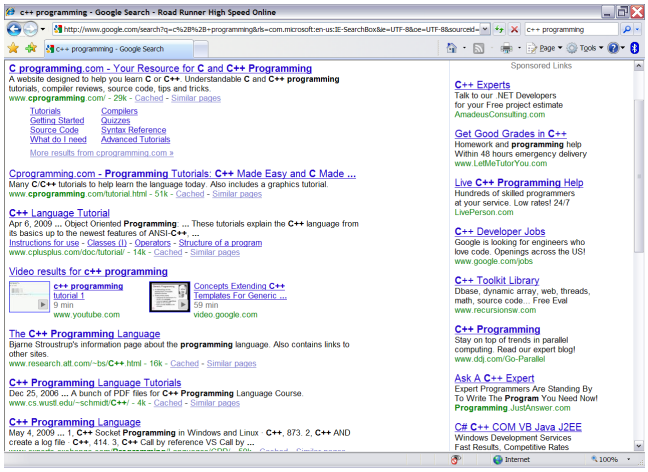

Figure 3 – search on "c++ programming

In this example, there is a prevalence of available tutorials in the first ten links.

Of the first ten links, the first one is a learning resource site (www.cprogramming.com/) and several are pointers to tutorials and Online help:

- 4 are information resources with pointers to other learning resources
- 3 are tutorials
- 1 is a FAQ
- 1 is an online manual (as a book on a wiki)
- 1 is a video demonstration (on youtube.com)

The wikipedia site is eighth in the return list and does not include a link to the site that was listed first in the search results. Here is what you see on that first site listed:

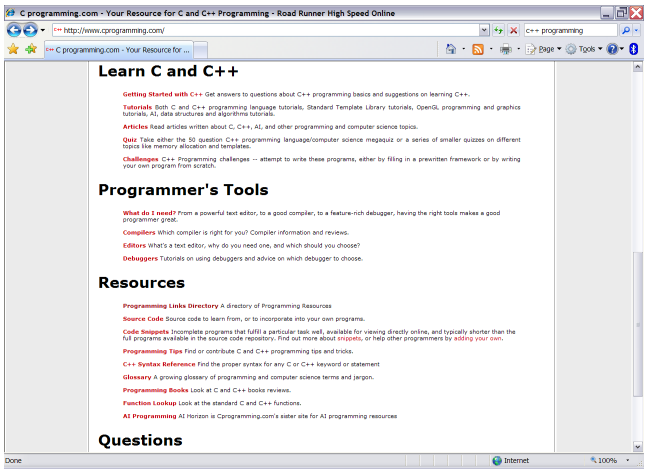

Figure 4 – what you see on that first site listed

4. METHODOLOGY AND RESEARCH HYPOTHESIS

The methodology used in his study consisted in first doing a bibliographical search to identify approaches of information resources and users or types of researching to a group of authors. To conduct the study we used a quantitative methodology, since the problem is related to understanding the use of several types of information resources in education.

We chose a university setting to conduct a collection of input by distributing a questionnaire. The survey was limited to information systems and computer science students. The questionnaire was designed to collect data and identify where students obtain information to solve their needs, and whether they preferred those resources listed on the survey or there were other ones they used. All of the surveys were personally administered, in order to clarify any doubts and to ensure an almost 100% response.

The questionnaire was composed of closed questions within a set of alternative responses. For each question there were eight types of information resources and for each one the student could answer according to a 5 points Likert scale. The sample was composed by 52 individuals, which are classified as in the Table 2.

Table 2. Questionnaires by Type of Students

Students´ Level	Number of Students	Computer science Background
Undergraduate Students	25	0
Post-Graduate Students	13	4
MSc. Students	14	14
Total	52	18

Based in a context where students have already some knowledge of programming languages, we analyze what are the main sources used and preferred by students either to improve knowledge or to solve specific problems.

All the students had at least one course of computer programming. All of the students needed programming skills, either in work or in the other courses of the program that they were attending, although their needs were different, because some were advanced programmers (such as C and Java) and others used programming only end user programming setting (such as Visual Basic applications).

The collected data was treated statistically. The differences of means were analyzed concerning use and preferences by different types of various resources of information.

Although many innovative technological improvements are in place in many of the newer forms of information and training, we wanted to see, through our survey results if user attitudes are becoming more favorable towards these newer forms and whether learning and information resource innovations are proving to be successful or not. We also wanted to see if user experiences contributed to a positive or negative image of some forms of e-learning.

5. RESULTS

In this section, the following two terms represent the two most common forms of technical content:

- Online help - Manuals or other forms of user assistance that is available on a Web site (such as a tutorial, a programmer's guide, reference information, white papers, and samples).
- Product help - Digital product documentation that is part of a help system or an external resource such as a documentation CD that is included as part of the product.

These terms are used in each of the tables in this section to represent these two common types of information.
Student surveys indicated that online help is the most used as well as the best and the easiest information resource when they felt the need to improve their knowledge on programming.

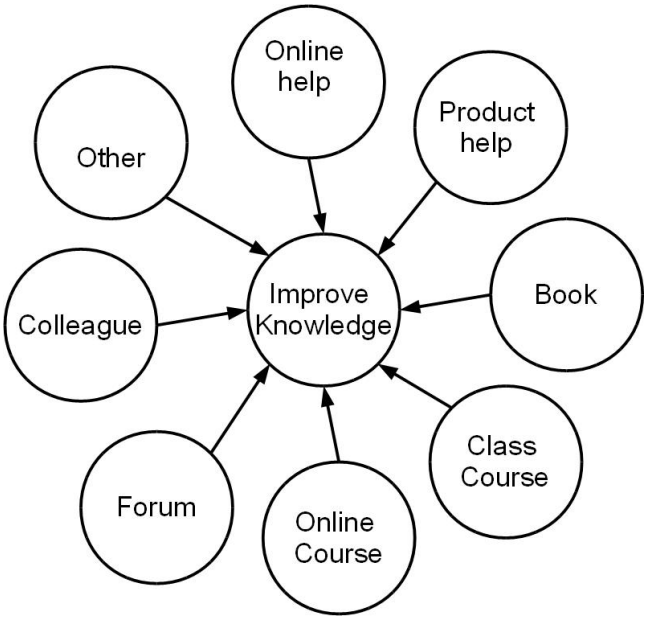

Figure 5 – Improve Knowledge

In general students gave more importance to online help, colleagues, and product help than to other types of information resources. At the bottom of the scale for their preferences are online courses, other resources available on the Internet and intranets, and classroom courses.

According to the results, table 3, students said that they usually used online help and colleagues when they needed to improve knowledge.

Table 3. Improve Knowledge of Programming Knowledge (e.g. PHP, VBA, C, and JAVA)

	Preferences		Uses	
	M	SD	M	SD
Online help	3.75	1.22	3.81	1.18
Product help	3.46	1.13	3.15	1.13
Book	3.35	1.19	3.08	1.30
Class Course	3.23	1.32	2.60	1.26
Online Course	2.56	1.06	2.08	1.03
Forum	3.15	1.15	3.21	1.76
Colleague	3.71	0.93	3.67	0.99
Other	2.75	1.00	2.75	1.04

M - Sample Mean

SD – Sample Standard Deviation

Students prefer online help and colleagues when they face a specific problem rather than online courses and class courses. Comparing differences on the results with the previous table Forums are more preferred in the situation of looking for an answer to a specific problem. But users frequently first go to a colleague to get information to solve a specific problem and then they go to online help. Students say they use colleagues and then online help more than other information resources. Again, class courses and online courses are listed as the last resource options.

When referring to other resources they point out search engines (such as Google). According to the results, a search engine on the Internet is also considered and used as an information resource.

From Table 4, we may verify that online courses are different from all the other sources of information.

Table 4 Improve Knowledge of Programming languages e (preferences)

	Digital manual	Book	Class Course	Online Course	Forum	Collegue
Online help	0.22	0.09	0.04	0*	0.01*	0.86
Product help		0.62	0.35	0*	0.18	0.23
Book			0.64	0*	0.41	0.09
Class Course				0.01*	0.75	0.04
Online Course					0.01*	0*
Forum						0.01*

* p <0.025

In Table 4 we analyzed what extends the differences of the means and show that these difference are significant. Those tables present the significance level corresponding to the t-Student tests, comparing the means of the variables presented.

We used a level of significance of 0.025. Consequently, if values are inferior to this level of significance the null hypothesis of equality of mean may be rejected.

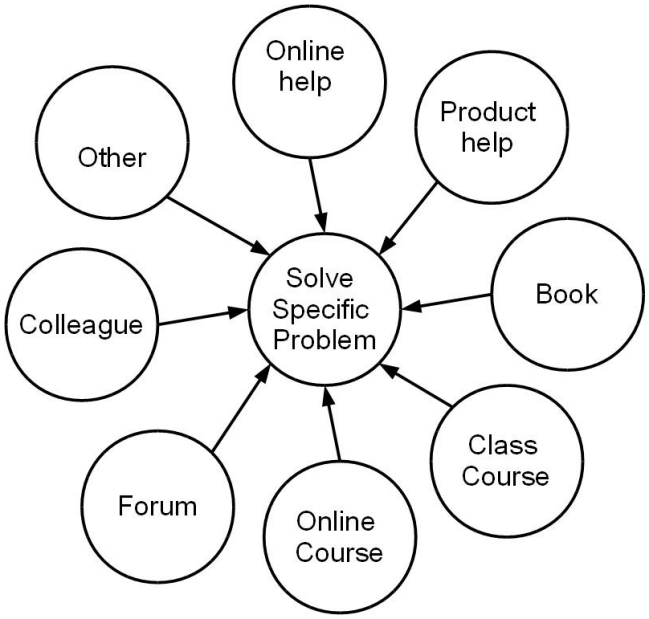

Figure 6 – Solve specific Problem

Table 5. Preferences and Uses for a Specific Problem

	Preferences		Uses	
	M	SD	M	SD
Online help	3.88	1.19	3.83	1.20
Product help	3.38	1.16	2.98	1.20
Book	2.98	1.26	3.04	1.34
Class Course	2.67	1.30	2.38	1.21
Online Course	2.31	1.14	2.06	1.08
Forum	3.10	1.33	3.12	1.37
Colleague	3.87	0.96	3.96	0.96
Other	2.85	1.03	2.87	1.13

M - Sample Mean

SD – Sample Standard Deviation

We may also compare correlation between use and preference. High correlation between the two, suggests that students behave in the same way, in what concerns preferences and usage.

Comparing the information sources used and preferences for knowledge improvement in programming languages, we verify that correlation is low, except for on-line manual.

Table 6 Correlation between uses and preferences (improve knowledge)

Source of Information	Coefficient of correlation
Online help	0.86
Product help	0.65
Book	0.62
Class Course	0.59
Online Course	0.31
Forum	0.50
Colleague	0.48
Other	0.76

If we analyze the problematic of "solving a specific problem", we identify that colleagues is the source of information corresponding to a low correlation in opposition to all the others.

Table 7. Correlation between uses and preferences (solve specific problem)

Source of Information	Coefficient of correlation
Online help	0.87
Product help	0.72
Book	0.92
Class Course	0.73
Online Course	0.71
Forum	0.83
Colleague	0.35
Other	0.78

These examples are coherent with the findings in this paper as to what information and what kind of information is available from the Web for learning about programming and how to write programs.

6. DISCUSSION

The results presented in this paper are consistent with findings presented by other researchers , where colleagues ("ask others") play an important role. Books (printed manuals) are generally less proffered and also less used. Here, other sources are presented – e-learning and classes in classrooms. Specially, e-learning is not very appealing to students.

Students feel no need of extra courses (class/ online) either because they were on courses at the time they were questioned or because they feel they had the knowledge to look for information themselves, without supervision.

Those results are especially important for teachers of programming languages. In fact, the attitude of the students towards classes and e-learning is not very good. But it gives some clues. Specifically, the use of collaborative platforms may be an answer to the need of consulting colleagues.

On the other hand, the suggestion of some on-line resources and the contribution for the production of on-line resources is also suggested.

On the other hand, results presented here are also relevant for those that produce manuals. Writers of printed manuals must shift to on-line manuals.

Obviously results does not answer the problem of effectiveness and efficiency of each method. In fact, results presented here are based on the answers of the users of the information, not the results of work performed by them.

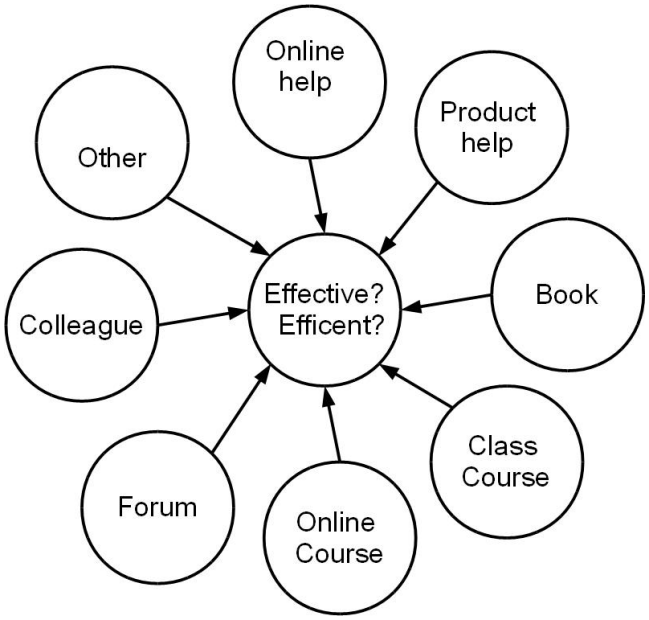

Figure 7 – Effectiveness and Efficiency

7. CONCLUSION AND FUTURE WORK

Students feel no need for extra courses in classrooms or online either because they were taking courses at the time they were questioned or because they feel they had the knowledge to look for information themselves, without supervision.

From the results, we can conclude that they also prefer online help much more than they usually use product help. This may be due to some reasons such as that online help tends to be more up-to-date than product help and online help can be used to solve and fix problems more quickly. For example, it is quicker to search on Google, find a link to information, and utilize it, than referring to product help to search for and find information to solve a given problem.

Additionally, referring to colleagues seems to be the second most common information resource and, just as for online help, is preferred and used by students. The reasons for choosing these resources is likely the short amount of time needed for searching for and finding answers to questions, and students trust colleagues more than information found in forums.

ACKNOWLEDGMENTS

This paper is partially supported by FCT – Portuguese Ministry of Research and Development and High Education

REFERENCES

[1] Pirolli, P. and Card, S. K. (1999). “Information Foraging”. Psychological Review, 106(4), 643-675

[2] Metropolis, N. Howlett, J. and Rota, Ged., A History of Computing in the Twentieth Century, New York: Academic Press, 1980.

[3] Kernighan, B. (1981) Why Pascal is Not My Favorite Programming Language. Murray Hill, New Jersey: AT&T Bell Laboratories, 1981.

[4] Pérez-Quiñones, M. (1998) "Teaching History of Programming Languages to Undergraduate Students" Published at Frontiers in Education 1998 (FIE’98), Tempe, Arizona, November 4-7, 1998

[5] Hauswirth, M. Jazayeri, M. and Winzer, A. (1998) "A Java-based environment for teaching programming language concepts" - Frontiers in Education Conference, 1998. FIE '98. 28th Annual, Vol1 pp. 296-300.

[6] Christiansen, H. (2004) "Prolog as description and implementation language in computer science teaching". M. Ducassé, U. Nilsson, D. Seipel (Eds.). Proceedings of The First International Workshop on Teaching Logic Programming - TeachLP . September 8-9, 2004, Saint-Malo, France. pp. 43-54.

[7] Christiansen, H. (2004) “Teaching computer languages and elementary theory for mixed audiences at university level.” Computer Science Education Journal, Volume 14, Number 3, September 2004. pp. 205-234.

[8] Perez, J. ; Ruiz, P.e ; Gonzalez, M (2003) "A development Web environment for learning programming languages" ICWE 2003 : international conference on web engineering, Oviedo , Spain , vol. 2722, pp. 128-129,

[9] Morrison, E. W. (2002). Information seeking within organizations. Human Communication Research, 28(2), 229-242.

[10] Ulloa, M. (1980) Teaching and learning computer programming: a survey of student problems, teaching methods, and automated instructional tools, ACM SIGCSE Bulletin, v.12 n.2, p.48-64.

[11] Smart, K., Whiting, M., and De Tienne, K (2001). Assessing the need for printed and online documentation: A study of customer preference and use, Journal of Business Communication 38, 285--314..

[12] Burk, C. and Horton, F (1988), InfoMap: A Complete Guide to Discovering Corporate Information Resources, Prentice Hall, New Jersey

[13] Mantufar-Chaveznava, R. Yousuf, M. and Hernadez, V. “Web Techmology for Engineering and Computer Science Learning” Information Technology, Organizations and Teams, ITML Press.

[14] Choo, C. W. (1994). “Perception and use of information sources by chief executives in environmental scanning”. The Library & Information Science Research, 16, 23-40.

[15] Kuhlthau, C. C. (1999). “The role of experience in the information search process of an early career information worker: Perceptions of uncertainty, complexity, construction, and source.” Journal of the American Society for Information Science, 50(5), 399-412.

[16] Culnan, M. J. (1985). “The dimensions of perceived accessibility to information: Implications for the delivery of information systems and services”. Journal of the American Society for Information Science, 36(5), 302-308.

[17] O’Reilly III, C. A. (1982). Variations in decision makers’ use of information sources: The impact of quality and accessibility of information. Academy of Management Journal, 25(4), 756-771.

[18] Gerstberger, P. G., & Allen, T. J. (1968). Criteria used by research and development engineers in the selection of an information source. Journal of Applied Psychology, 52(4), 272-279.

[19] Yitzhaki, M, & Hammershlag, G. (2004). Accessibility and use of information sources among computer scientists and software engineers in Israel: Academy versus Industry. Journal of the American Society for Information Science and Technology, 55(9), 832-842.