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Educational Science CD-ROM Utilization

An Investigation of Science Software Programs in the K-12 Classroom

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Abstract

With the continuing push for instructional technology in our nation's schools, many science institutions have risen to the challenge by developing and disseminating a variety of educational science CD-ROMs. Unfortunately, there has been little research to determine the characteristics of successful science educational CD-ROMs, leaving developers with little guidance in this costly endeavor. For this purpose, the NASA Solar System Exploration Education and Public Outreach (SSE E/PO) Forum executed a research study on the utilization and effectiveness of science educational CD-ROMs, focusing on educational CD-ROMs developed by NASA. This study will highlight a number of barriers that impede educators from using CD-ROMs in the classroom, and provide guidelines for the development of quality educational CD-ROMs that will serve a need in the educational community.

1. INTRODUCTION

Since the introduction of computer technology in the K-12 classroom, science educators have been flooded with a seemingly endless flow of educational CD-ROMs. Thousands of software developers have contributed to this new trend in educational technology by joining the race to develop the latest, most high-tech educational science software programs in the industry. In this rapidly changing field, every advance seems to promise new hopes and success, and the analysis of the previous educational software models becomes irrelevant. As a consequence, virtually no preliminary research has been done in the development of these models, and developers have been left to make educated guesses as to what features and qualities of CD-ROM programs the K-12 educational community prefers and actually uses (Ehrmann 2001).

This negligence has lead to a disappointing outcome in our nation's classroom. It appears that many of these exciting, high-tech, multimedia educational programs that CD-ROM developers have revered are scarcely being used in the K-12 science classroom (Becker 1999; Education Market Research 1999; McKenzie 1999; Rowand 2000). According to Pompea and Morrow (2000), "too many well-intended CD-ROMs have become little more than drink coasters." While the educational CD-ROM developers may have good intentions, these intentions do not directly translate into educational value (Pompea & Morrow 2000).

In order to provide quality educational CD-ROM programs for our nation's science educators, developers must first seek to know their customers, their needs, and their challenges. This paper provides an in-depth analysis of the needs of our nation's science educators in terms of science educational software. The first part of the article explores the literature relating to the needs of our nation's K-12 educators and the barriers they face in using educational CD-ROMs in their instruction. The remainder focuses on a study conducted by the NASA Office of Space Science Solar System Exploration Forum, which examines the use of educational science CD-ROMs in the K-12 classroom--and in particular the use of NASA-produced science educational CD-ROMs. This paper will demonstrate that the lack of widespread usage of educational CD-ROMs can be rectified by a more careful consideration of the barriers in the educational community, and by emphasizing the quality of the CD-ROM *curriculum* rather than the delivery mechanism.

1.2 Educational CD-ROM Categories

Before we can elaborate on this topic, it is necessary to clarify and define the term "educational CD-ROM." There is a wide variety of CD-ROMs on the market that are defined as educational, ranging from basic data archives to robust curriculum packages. Pompea and Morrow have defined five general subtypes of educational CD-ROMs:

Data archive/image archive: Data with limited explanation of contents or guidance about how to use or navigate the archives. Data often are in catalogs in ASCII form, and images are often compressed.

Data/image library: Collections of well-organized data and imagery with explanatory notes and any software tools needed for viewing. Explanatory material may be in the form of QuickTime movies.

Teacher resources: Lesson plans or classroom activities that use movies, images, and simulations. Extra data and background information may be provided also.

Interactive lessons for students: Purposeful interactive lessons or structured activities that allow students to learn science content or process skills. May also include teacher resources and evaluation instruments. Very strong and extensive teacher resource areas. Links to other content on the Web, and strong awareness of national science standards.

Full-featured instructional package: Includes some of all of the above categories. Organized to promote student inquiry and to support student research. Usually a strong emphasis on science process and has a problem-centered, investigative approach. Shows strong awareness of learning cycle with exploratory activities, as well as activities involving knowledge synthesis and going further (Pompea & Morrow 2000).

The remainder of this paper will focus on the latter category of CD-ROMs, which are full-featured instructional packages.

2. LITERATURE SEARCH

Existing research concerning the use of CD-ROMs in the K-12 classroom is sparse and tells little about the impact that this technology has on student learning. According to Larry Cuban (2000), "there’s been a lot of research...and a lot of anecdotal evidence, but no body of serious research to measure whether technology will achieve its own goals." Most research studies to date have focused on the first level of intervention--that is, the use of educational technology by classroom educators. These studies have indicated certain trends. The most relevant conclusion has been that science educators face almost insurmountable obstacles in the implementation of educational science software in the classroom. Because of these barriers, many CD-ROMs never make it to the intended customers, the students. The obstacles to using educational technology include but are not limited to: (1) time constraints, (2) expense of CD-ROMs, (3) hardware limitations, (4) curriculum standards pressures, and (5) poor quality of CD-ROM programs.

2.1 Time Constraints

Effective use of educational CD-ROMs in instruction requires a great deal of time on the part of the educator, including time to prepare for its use, search for appropriate titles, and employ the program in the classroom.

2.1.1 Preparation Time

Unlike many other professions, being an effective educator requires countless hours of at-home preparation each day. Most educators’ days are filled with preparing what is required and familiar, leaving little to no time to determine how to use and integrate a new CD-ROM program. Several studies have found that one of the greatest barriers for educators to include CD-ROMs in their instruction is the amount of preparation time necessary to do so (Education Market Research 1999; Hoff 1999; U.S. Department of Education 2000). Further studies have indicated that many educators do not use CD-ROMs because of lack of release time to practice, plan, and learn how to use the technology (Marsh, Ringstaff, & Yocam 1996; Trotter 1999).

2.1.2 Time to Find Appropriate CD-ROMs

Associated with preparation time is the time required to search for appropriate educational CD-ROM titles. There are countless educational science CD-ROMs, and unlike textbooks, most school districts have no formal process for reviewing and approving these titles (Education Market Research 1999). As a result, most teachers are left to sift through mountains of CD-ROM titles with no indication of which are quality, educationally sound, and applicable to their needs (Hoff 1999; Peters 2000). According to Zehr (1999a), "truly exceptional software gets lost in the shuffle. With so many software titles...to choose from, it can be difficult and time consuming to find the good stuff." Many science teachers have become frustrated with this nearly insurmountable task, and therefore have avoided using educational CD-ROM programs altogether.

2.1.3 In-class Time

Even if educators are able to find appropriate CD-ROMs and take the time to learn how to incorporate them, most will not have adequate time to use them to their full potential in the classroom. Associated with using a CD-ROM in the classroom is the time required to set up equipment (computers, projection devices, and so on), handle technical problems, and train the students on how to use the software (Zehr 1999b). While some schools are more advanced, most provide no more than one or two hours a week for students to use computers, less than 10 percent of their instruction time (Cuban 2000). The majority of the science classroom time is already "packed" with mandated curriculum content (Hoff 1999; Trotter 1999), and most educators are uncomfortable deviating from the obligatory tasks long enough to implement complex CD-ROM programs.

2.2 Expense of CD-ROMs

The expense involved in purchasing the software and inserting it into teaching practices is another major obstacle to its use. In fact, many educators perceive this expense as the largest barrier to making greater use of educational CD-ROMs (Education Market Research 1999). Educational CD-ROMs are usually quite expensive, and science educators generally are not provided funds from their school districts to pay for them. One study found that approximately one out of every five teachers who use instructional software pays for it out of pocket (Education Market Research 1999). Because most educators must live on a limited budget, the great majority cannot afford this luxury. This challenge has lead to a national problem commonly known as the "digital divide," referring to the division between the high availability of technology for more affluent schools and the absence thereof for high-poverty schools (Becker 1999; Education Market Research 2000; Market Data Retrieval 2000; Zehr 1999).

2.3 Hardware Limitations

Hardware limitations in the classroom contribute to the difficulties of using educational CD-ROMs. Although the number and capacity of computers in our nation’s schools have increased dramatically over the past 10 years (Anderson & Ronnkvist 1999; Williams 1999), many schools still do not have the hardware capacity to use educational CD-ROMs as they are intended (U.S. Department of Education 2000). The lack of classroom computers in general is one of the most common reasons teachers do not use CD-ROMs in instruction (Education Market Research 1999; Milken Family Foundation 1999; Potter 2001). Often there are only one or two computers in a classroom--and often in nearly inaccessible areas--providing little opportunity for a CD-ROM to be used simultaneously by the entire class (Anderson & Ronnkvist 1999; Ravitz, Wong, & Becker 1999). Even more common, however, is the situation where there are enough computers in the classroom, but the computers are old, slow, unreliable, and/or not powerful enough to display the multimedia components that so many CD-ROMs contain (Education Market Research 1999; Milken Family Foundation 1999).

2.4 Testing/Standards Pressures

Within the last decade, there has been a shift in our national education policy towards required curriculum standards and assessment, a movement that has had a profound impact on our nation’s schools (Potter 2001). Most educators today feel that they are under extreme pressure to cover required curriculum content and prepare their students for standardized testing (Goldman, Cole, & Syer 1999; Potter 2001;

Ravitz et al. 1999). Because of these pressures and the limited time allotted to use instructional technology, "if the digital content doesn't help achieve specific curriculum goals, many teachers don't want it" (Hoff 1999). Do the majority of educational science CD-ROMs help teachers achieve their curriculum goals? The answer appears to be No. According to a study conducted by Education Market Research (1999), 59% of teachers give the CD-ROMs in their classrooms a letter grade of C or lower when it comes to matching with state and district tests, and 46% of teachers admit that the extent to which their educational CD-ROMs match their state or district curricula is a "big" or "moderate" problem. It appears that for most science teachers, "it's very hard to find exactly the right piece of software that will work reliably, not lose students' interest, and...meet the requirements of the curriculum" (Cuban, as cited in Fatemi, 1999).

2.5 Quality of CD-ROM Programs

Although there are several exceptional science CD-ROMs on the market, many are of inferior quality (Smith 1996). "The depth, the appropriateness, the correctness of the content that is being provided--that's where there are some people who are saying the software we have today doesn't go far enough" (Roberts, as quoted in Zehr 1999a). A large majority (75%) of teachers who do not use CD-ROMs in their instruction have indicated that the quality of the CD-ROMs is a major deterrent (Education Market Research 1999). Unfortunately, few evaluations have been done to help educators identify high-quality science CD-ROM programs (Zehr 1999a), and often educators are exposed to low-quality programs that discourage them from using others in the future.

2.5.1 Ease of Use

Several features weaken the quality of an educational science CD-ROM. The first is a difficult interface that does not ensure ease of use. A good CD-ROM must have clear instructions, easy navigation, and be easily controlled by the user (Gooden 1996). If students and educators cannot quickly determine how to use a CD-ROM, it will, in all likelihood, be put aside and never used again.

2.5.2 Quality of Content

While the first push in educational technology was simply to get computers and software into the classroom, educators are now focusing on what kind of content to put on them (Solomon 1998; Zehr 1999a). Like textbooks, educational science CD-ROMs must contain accurate, robust, and up-to-date information within their contents. The contents also must be of sound educational value and result in student learning (Potter 2001). Unfortunately, this level of quality is not always attained for educational science CD-ROMs on the market (Smith 1996).

2.5.3 Interactivity

One of the greatest indicators of quality in an educational CD-ROM program is the level of interactivity it offers. When students can interact with a program and influence the outcomes of the activities, they become engaged and motivated (Archer 1998). Unfortunately, too many of the educational science CD-ROMs on the market are comparable to "digital textbooks," offering little more than reading and looking at images (Hawkins 2001). To be effective and keep a student's interest, technology must offer something that a textbook cannot (Potter 2001).

2.5.4 Student Learning

No matter how exciting, entertaining, and elaborate an educational CD-ROM is, if it does not result in student learning, educators will not be satisfied (Goldman, Cole, & Syer 1999). Educators "want assurance that computers in the schools are more than expensive and entertaining toys; they desire evidence that educational computer use truly enhances learning in demonstrable ways" (Cotton 1999). Three major features of science educational software have been linked to enhanced student learning.

1. The first feature involves the capacity for students to practice what they have learned after working with the CD-ROM. According to Suppes, a professor of philosophy at Stanford University:

   > People who don't recognize the need for practice are only romantics out of touch with the real world. Can you imagine learning how to play basketball by only listening to a lecture and participating in discussions with critical thinking? I would consider it an example of poor quality to offer a student software...and no opportunity for practice (as cited in Zehr 1999b).

   There are two prominent types of practice elements among education CD-ROMs. The first, commonly known as "drill and practice," requires students to simply memorize and regurgitate facts. The second, known as open-ended exploration, allows students to become engaged in applying the information presented (Zehr 1999a). The recent shift in educational paradigms towards constructivism has caused many to criticize "drill and practice" software, because while it does deepen understanding, students learn nothing new in the process (Archer 1998; Solmon 1998; Trotter 1999). In 1999, Wenglinsky found that students who used computers for open-ended exploration performed better on national tests than those who used computers primarily for drill-and-practice (as cited in Archer 1998).

2. The second feature of an educational CD-ROM that helps promote learning is the capacity to allow different students to work at different levels. A quality CD-ROM should allow students to work at different levels (Potter 2001). Many educational software reviewers agree that a good program will have the capability to automatically adjust its skill level based on the students' responses, giving advanced students more "running room" to work ahead of others (Zehr 1999b).

3. The third feature of a program linked to enhanced learning is the capability to provide feedback to the student. One of the greatest benefits of using technology to teach a concept is that a computer allows students to answer questions privately without the risk of being embarrassed or scolded by the teacher (Cotton 1999). Without feedback, not only is the program not taking advantage of this enormous learning opportunity, but the student will be given no indication of whether he or she is on the right track (Goldman et al. 1999). The feedback given to students may vary, but instructive, explanatory feedback is much more effective than simple Yes or No responses (Archer 1998).

2.5.5 Assessment

The final element of a quality science CD-ROM is the capacity to assess students' progress and provide that information to the teacher. If a student's progress is not tracked, the supervising teacher will have no indication of whether the student has actually learned anything in the time spent with the software. One of the benefits of tracking each step of the student's progress for later review is that it gives insight into the student's thought process (Lawton 1998). "It's the closest I think [teachers] can get to getting inside their students' minds" (Hershball, as cited in Lawson 1998).

3. STUDY RATIONALE

While the literature search provided meaningful insights into the difficulties educators face in implementing science software programs, several factors need further investigation.

- The literature did not provide a clear picture of which science software programs are most favored by educators, which components they prefer, and why.
- Little insight is available on how educators specifically utilize software programs in the classroom or how frequently they use them.
- No large-scale study has focused exclusively on *science* software programs, or, more specifically, on science software programs developed by major science institutions such as the National Aeronautics and Space Administration (NASA).

It is for the preceding that the NASA Office of Space Science Solar System Exploration Forum has conducted this study.

3.1 Methodology

The study consisted of both quantitative and qualitative research. After a series of collaborations with a number of NASA's current educational CD-ROM developers, a Likert scale questionnaire was constructed to elicit quantitative data. The questionnaire was made available online, and an invitation to respond was sent by email to approximately 4,000 educators. These educators were chosen on the basis of having received one of the following CD-ROMs: *Visit to an Ocean Planet (TOPography EXperiment for Ocean Circulation)*, *Winds of Change (NASA Scatterometer Mission)*, and *Ways of Seeing (Cassini Mission to Saturn)*. To elicit a higher response rate, educational posters and CD-ROMs were offered to those who completed the questionnaire.

Qualitative data was gathered through a series of telephone interviews with the questionnaire respondents who had indicated they were willing to participate. All interviews were recorded to ensure quality and accuracy. Both forms of data collection were considered in the data analysis and conclusions of this study.

3.2 Demographics

The email invitation to respond to the questionnaire successfully reached 3216 educators. A total of 817 of these educators responded to the questionnaire, a response rate of 27%. The highest percentage of respondents represented teachers of grades 9-12 (44%), followed by 5-8 (36%) and K-4 (20%). The majority of respondents indicated they taught general science (58%), with specific disciplines in earth/space science, biology, environmental science, physics, physical science, and chemistry. There was a fairly even distribution among respondents' years of classroom experience, indicating that educators from all levels of experience use educational CD-ROMs. The distribution of educators from rural, urban, and suburban communities was also relatively even, and the majority of respondents (66%) were from schools with middle socio-economic levels.

Further investigation of the respondent demographics reveals discouraging findings about technology access in our nation's schools. As shown in Figure 1, the majority of respondents (58%) had only 1-3 computers in their classroom, and an additional 5% had zero computers. This finding has little variance across the United States, with the exception that rural schools have slightly lower percentages of classroom computers than urban schools. As one would assume, the 10% of schools with high socio-economic levels had higher percentages of classroom computers, but there was little difference in percentages between those whose levels were middle or low.

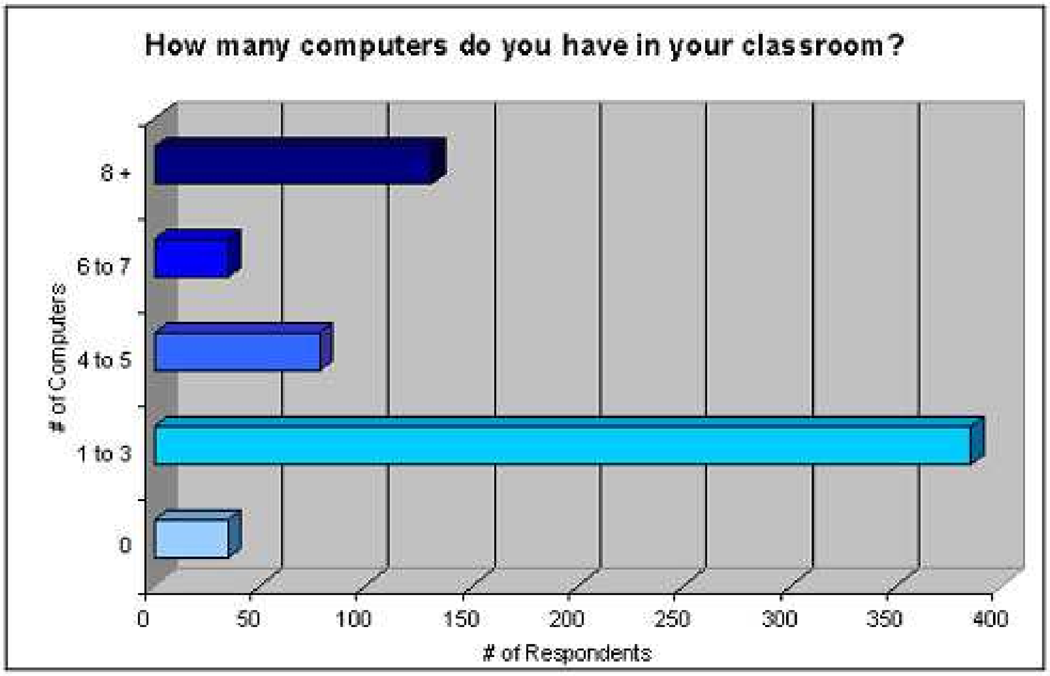

Figure 1. Number of classroom computers

3.3 Results

The first portion of the questionnaire revealed significant findings about teacher preparation and training in educational technology. A significant percentage of respondents (13%) indicated that they had yet to receive technical training during their teaching careers. Furthermore, the large majority (73%) had never undergone a NASA-sponsored training seminar or workshop. This indicates that 73% of educators were given an educational CD-ROM from NASA with no training or instructions on its use.

The next section of the questionnaire related to the question of educational CD-ROM selection and dissemination, to discover which method is most effective in reaching educators. The respondents rated the Internet as the most common source for finding educational CD-ROMs, rated above retail stores, training/workshops, and technical resource advisors. Respondents also indicated that their selection of educational science CD-ROMs is based primarily on recommendations from others. Many also indicated that the alignment of the CD-ROM content with their curriculum is an important factor in their selection process.

One of the key objectives of our research was to determine the degree of utilization of science educational CD-ROMs, primarily those developed by NASA. Thirty percent of the respondents indicated that the particular NASA CD-ROM they were given was never used in their classroom instruction. Reasons given for not doing so fell into three general categories: (1) technical difficulties, (2) lack of time, and (3) general dissatisfaction with the CD-ROM. This dissatisfaction includes complaints that the CD-ROM did not align with their curriculum, that it was not appropriate for their grade level, and that it was difficult and time-consuming to use. Others expressed that they were impressed with the CD-ROM, but did not have the hardware capability to use it with their entire class.

In contrast, seventy percent of respondents indicated that they had used the CD-ROM in instruction at least once. Some of these continued to make regular use of the CD-ROM in instruction. When asked which factors contributed to sustained use of an educational CD-ROM, respondents indicated that it depends primarily on whether or not the CD-ROM promotes learning for their students. Other indicators of sustained use include the ability to integrate easily into the curriculum, interactivity, accuracy of science content, allowance of individual student usage, and capability for assessment.

When asked whether CD-ROMs should be developed for use by the teacher (a "Teacher Resource CD-ROM") or for direct student use (an "Interactive Lesson CD-ROM"), the majority of respondents (67%) indicated that they prefer CD-ROMs that are developed as a teacher resource. Respondents were also asked which format is the best delivery mechanism of content--CD-ROM or Web-based--assuming they have an Internet connection in their classroom. Figure 2 illustrates that respondents in this survey indicated that, given a choice, they prefer to use CD-ROMs in their instruction to the Internet. When asked which delivery mechanism is preferable for the CD-ROM tutorial, respondents indicated that they prefer them in supplementary booklets (49%) or on the CD-ROMs (46%) rather than via videocassette.

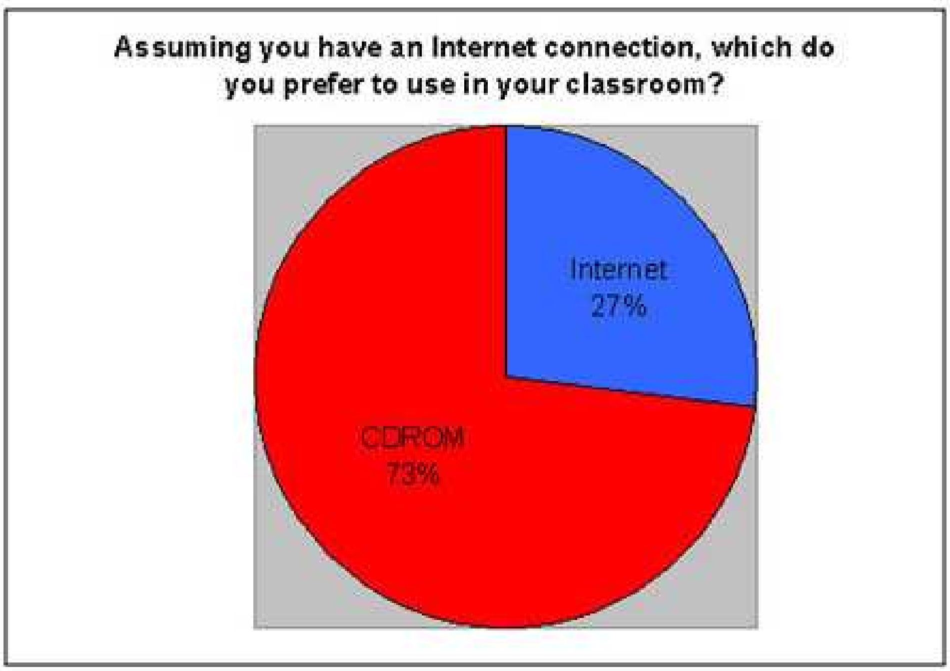

Figure 2. Do educators prefer CD-ROMs or the Internet?

3.3.1 Case Study: "Visit to an Ocean Planet" CD-ROM

The latter part of the questionnaire focused on the particular NASA educational CD-ROM that each respondent was given. For the purposes of this paper, only the results from the group of respondents that received the NASA *Visit to an Ocean Planet* CD-ROM is reviewed, based on the high volume of respondents from this population pool. The average preparation time required to use this CD-ROM was 4.07 hours, with responses ranging as high as 48 hours. The CD-ROM was used in classroom instruction an average of 10.1 times across respondents. The most popular classroom use of the CD-ROM was for *classroom demonstrations*, followed by *student research for projects*. Surprisingly, the CD-ROM was used least often as a computer lab activity.

Questions about the content of this particular CD-ROM revealed that educators seemed to be pleased with the science content included on the CD-ROM. Some other favorite aspects of the CD-ROM include the multimedia segments, the interactive components, the real-world connections to science, and the ease of use. However, many respondents indicated that they were dissatisfied with the CD-ROM content's lack of alignment with their required curriculum. Results also indicated that while the educators themselves found the CD-ROM content to be interesting, it did not always keep their students' interest. However, the qualitative data indicated that many educators were pleased with the CD-ROM's ability to keep their students' interest.

3.4 Discussion

The results of this study indicate that many educators are indeed satisfied with and making use of the science CD-ROMs they have received. However, the low usage of these CD-ROMs in the classroom indicates that there is certainly room for improvement. While educators respond favorably to the depth and accuracy of science content and the exciting visuals that NASA has to offer through its educational CD-ROMs, other crucial factors must be taken into account to reach all science educators, rather than just the self-selected NASA-attentive population.

If one truly intends to produce an educational science CD-ROM that will be utilized to its fullest extent, the preceding considerations must be taken into account. It will be necessary for many educational CD-ROM developers to take a step back and begin to consider the seemingly insurmountable barriers their customers face. When considering the preceding obstacles in the educational CD-ROM development process, producers will begin to set precedence for appropriate educational CD-ROMs that help rather than hinder our nation's science educators.

Because of the limited time educators have at home and in the classroom, science CD-ROMs must be designed in such a way that they require a minimal amount of time to prepare for instruction, and they must be simple enough to be used quickly in the classroom. The dissemination of these CD-ROMs is also crucial, and requires an appropriate strategy to reach the majority of educators who choose CD-ROMs based on word of mouth, and to ease the burden of locating and identifying the CD-ROMs for those who search on their own. Disseminating CD-ROMs through training or workshops is the optimal method for ensuring their use. Cost is also a crucial factor that developers must consider, understanding that science educators generally have little or no money to spend on classroom materials. Educational CD-ROMs must be designed so that they can be used with a limited number of computers, as well as with old, slow, unreliable hardware, or again they will have a minimal chance of being used.

Due to the pressure of required curriculum and high stakes testing that educators face, the content of the CD-ROM must be correlated with the science curriculum standards to which teachers must adhere, and should be standards-based and appropriate to replace the required science curriculum. By the same token, it is vital that the CD-ROM contains appropriate content that is scientifically accurate and educationally valuable, and that results in measurable student progress. The CD-ROM also must offer some level of interactivity that allows students to participate, become engaged, do something with what they have learned, and provide an assessment and feedback on their progress.

4. CONCLUSION

The intent of this paper is to offer research-based recommendations for educational science CD-ROM developers who truly wish to improve the state of education. A close examination of the preceding obstacles, which impede greater utilization of digital content, is a vital step in the development of all educational science CD-ROMs and will dramatically increase their effectiveness in our nation's schools. Once these factors have been taken into account, widespread use of the CD-ROM program cannot be ensured, but its likelihood will increase dramatically.

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