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Characterization and Analysis of a Science Curricular Resource on the World Wide Web:

The Cyber History of Bernoulli's Principle

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Abstract

The purpose of this study is to present an analysis of Web-based curricular resources associated with a specific science concept, Bernoulli's Principle. Teachers have a persistent need to identify curricular resources to meet the day-to-day demands of their teaching. They are turning to the Web as a resource for curricular materials, particularly for demonstrations and lesson plan ideas. We conducted a search for Web pages containing information on Bernoulli’s Principle using two of the most comprehensive World Wide Web search engines, AltaVista and HotBot. The search referenced a combined total of 583 Web pages of which 176 (30%) contained at least a short operational definition or graphic display of Bernoulli’s Principle. Each Web page was characterized using specific criteria. The Web contained a variety of lesson plans and ways to demonstrate Bernoulli's Principle. The trend toward an increasing number of educators gaining access to the Web and using it as a source of classroom materials may bring new problems. Many of the lesson plans and demos we surveyed lacked the complexity and depth of content found in the older (pre-1980) print materials. Very few sites provided the user with the opportunity to submit feedback or ask questions regarding the material featured in Web pages. There was a paucity of Web sites that exploited the dynamic capabilities of the Web, such as featuring video and simulations. The most disturbing finding of this study was the identification of a common misconception in the application of Bernoulli's Principle to the concept of lift in a large number of the sampled Web-sites. The presence of this misconception on the Web can be viewed as an "infection" by an alternative conception that can be rapidly propagated to a global audience. We suggest that the emerging field of memetics offers a promising approach to modeling the diffusion of Web-based alternative conceptions and curricular artifacts.

Introduction□*

Educators from all grade levels and subject areas have rushed to gain classroom connectivity to the World Wide Web (Flake, 1996). The percentage of K-12 public schools having access to the Internet has grown from 35 percent in 1994 to 89 percent in 1998 (National Center for Education Statistics, 1999). Commensurate with this growth, the percentage of classrooms connected to the Internet has increased from three percent in 1994 to 51 percent in 1998. This is, in part, because the World Wide Web (Web) has become a major repository of educational resources. A growing number of on-line sites provide easy access to lesson plans, classroom activities, demonstrations and other classroom tools (e.g., ERIC Clearinghouse, Eisenhower Clearinghouse, CRESST, and Access Excellence).

Teachers have a persistent need to identify readily available curricular resources to meet the day-to-day demands of their teaching. This fundamental need to address what a teacher will teach tomorrow lead Gomez, Fishman and Pea (1998) to declare that "the currency of the classroom is curriculum and activities!" Due to this inexhaustible need for classroom materials, practicing science teachers are turning to the Web for science content reference material, activities, and lesson plans (Wiesenmayer & Meadows, 1997). Likewise, pre-service teachers have found the Web to be a ready resource for curricular materials, particularly for demonstrations and lesson plan ideas.

Given the growing dependence of pre and in-service teachers on the Web as a resource for curricular resources, we felt it was important to undertake a systematic investigation of the number, location, diversity, and quality of science curricular materials available on the Web. This is all the more important given that we are still in the earliest stages of Web's evolutionary history. This study presents a comprehensive analysis of a set of Web-based curricular resources associated with a specific science concept, Bernoulli's Principle. Our research is intended to serve as a foundation for future studies examining how science curricular materials are developed, modified, and diffused across the Web and into science education settings.

Science Education on the World Wide Web

The adoption of the Internet and the World Wide Web as a tool for teaching and learning in the science classroom is a very recent phenomenon. The Handbook of Research on Science Teaching and Learning (Gabel, 1994) does not contain a single reference to the Internet or the Web. Since the early 1990's the Internet, with the advent of the Web as its graphical interface, has exploded on the science education scene. The rapid growth and proliferation of the Web as a classroom resource is apparent upon examination of Web66 (http://coled.umn.edu/schools.html), the International School Web Site Registry. Web66 is the oldest and most comprehensive database of K-12 schools on the Web. The first registered Web site in a K-12 school was established at the Illinois Academy of Science in 1993. By September of

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1995 one thousand schools were registered. Today (February 1999) there are more than 15,000 schools referenced in the Web66 database.

The Web is being integrated into science and mathematics classroom contexts in a number of different ways (reviewed in Wallace & Kupperman, 1997; Gomez et al., 1998; Day, 1998). Teachers and students increasingly use the Web to conduct on-line inquiry-based projects and to gather content information on a particular subject (Wallace and Kupperman, 1997; Rakes, 1996; Lyons et al., 1997). The Web is also being integrated into the classroom as a tool for teaching (Leu, et al., 1997; Leyden, 1997; Shotberger, 1996; Wright, 1998) and provides a medium for students and teachers to publish their work (Friedland and Webb, 1996; Keating & Talbot, 1999). In addition, teachers employ the Web to gather lesson plans and activities for classroom use (Martin, 1997; Rakes, 1996; Williams, 1997). The Web provides a platform for high schools and universities to deliver on-line courses (Collins, 1997; Shotberger, 1996; Smith and Taylor, 1995). Finally, there is an increasing interest in using the Web as a professional development environment for teachers (Hammer & DiMauro, 1996; McMahon, 1997; Slough & McGrew-Zouvi, 1996.)

Research studies on the World Wide Web in education have primarily focused on the "use" of the Web within classrooms rather than on the Web-based resources themselves (reviewed by Owston, 1997; Shotberger, 1996; and Windschitl, 1998). From a teacher's point of view, Web-based resources must have great practical value. For example, Wiesenmayer and Meadows (1997) worked with West Virginia Teachers to assemble Web-based resources for a watershed curriculum project. They described the Web as providing a "vast array of resources" for science educators. These resources included graphics, lesson plans, sound files, documents, data, and software. The Web also provided these teachers with access to on-line communities of researchers, educators, and hobbyists.

Diffusion of the Web as an Innovation

With the Web offering educators unprecedented access to curricular resources, we hypothesize that the nature of how these materials are developed, conceptualized, and adapted to local contexts will evolve in unforeseen ways. Norman (1993) argues that "even when technology is predicted properly, it is rare that anyone truly understands its real impact." He characterizes the implementation of technological innovations as a long, slow process of "mutual accommodation", where the technology and society gradually adjust their behavior and structure. Rogers (1995) identifies three stages in the diffusion of innovations; adoption, implementation, and reinvention. Rogers points out that as innovations diffuse they often undergo a process of reinvention. He states:

> Potential adopters on many occasions are active participants in the adoption and diffusion process, struggling to give their own unique meaning to the innovation as it is applied in their local context. Adoption of an innovation is thus a process of social construction. (page 179)

Many web sites are modeled after familiar, well-established print materials such as reference and textbooks (Habermann, Burton, & Frender, 1998; Owston, 1997). This allows teachers to have easy access to a large number of resource materials within a familiar setting that often resembles an on-line library. However, Habermann, Burton, & Frender (1998) argue that the full potential of the Web environment is not being fully realized. They envision the Web supporting "an information arcology" where users can interact with information and mold it according to their own needs. They suggest that we are in the early stages of the creation and diffusion of Web based resources for science students and teachers.

This study serves as a foundation for future efforts to track the implementation, reinvention, and diffusion of science materials on the Web. Tracking the diffusion process will require new approaches to science education research and studies that are longitudinal in scope. Efforts to archive or characterize the Web in its early stage of development can serve can serve as a vital record for educators, historians, businesses, and governments (Kahle, 1997). In this paper we characterize the presence of Web-based curricular resources featuring Bernoulli's Principle, a common physical science concept covered in K-16 classrooms. We are recording the "cyber history", the technological equivalent to "natural history", of this science concept in the Web environment. Bernoulli's Principle, in brief, states that the pressure in a fluid decreases as the velocity of the fluid increases (Hewitt, 1998).

We chose to examine Bernoulli's principle for four reasons. First, there is a long history of Bernoulli's Principle in science curriculum print materials. We inspected a wide range of science textbooks, science teaching methods books, and science activity books for representations of Bernoulli's Principle from the 1930's to the present to serve as a basis for comparison (e.g., Bosak, 1998; Herbert 1953; Joseph, et al., 1961; Liem, 1987; Lynde, 1939). Second, Bernoulli's principle crosses a large number of science content areas (general science, physics, and aeronautics) and is included as part of the science curricula in elementary through university courses. Third, the term Bernoulli's Principle is ideal for a well defined search of the Web. Fourth, over the years, a wealth of activities demonstrating Bernoulli's Principle have accumulated as part of science teachers' "bag of tricks". This set of activities has been reinvented and disseminated with each generation of science education reform and attendant theoretical approaches to science learning.

Methods

Based on the findings of Lawrence and Giles (1998), we conducted a search for Web pages containing material on Bernoulli’s Principle using two of the most comprehensive World Wide Web search engines, AltaVista (http://www.altavista.com) and HotBot (http://www.hotbot.com). Theoretically, this approach would enable us to sample more than 50% of the indexable Web sites (Lawrence and Giles, 1998). The phrase "Bernoulli's Principle lesson" was submitted to the AltaVista search engine on August 11th, 1998. This was not an "exact phrase" search, therefore the search words did not necessarily appear together within each of the Web records listed in the search results. A second search was performed using the HotBot search engine on October 13th, 1998. This search was for the exact phrase "Bernoulli's Principle."

A Web page may be a single page within a larger Web site. To avoid confusion between the words page and site, we will refer to the Altavista and HotBot search results as Web pages and the site containing a referenced Web page as a Web site. Each Web page referenced within the search results of the Altavista and HotBot search engines was visually examined to determine whether it contained an operational definition of Bernoulli’s Principle. Web pages containing at least some form of a definition or graphic display of Bernoulli’s Principle were recorded in a categorical database.

Each of the Web pages in the database were characterized using the following criteria: 1) the format of the presented material (i.e. text, graphics, QuickTime movies, simulations), 2) the target audience, 3) the originator of the site (i.e. private company, higher education, museum, individual, etc.), 4) the main topic being addressed, 5) the context within which Bernoulli's Principle is presented (due to the lack of information on many of the pages, the home page associated with each page was accessed to determine the general context or content area for that site.), 6) the type of feedback mechanisms, if any, available (i.e. email, an electronic form to submit, phone number, or traditional mail), and , 7) the presence or absence of a lesson plan or demonstration. To be classified as containing a lesson plan, a Web page must have included at least three of the following characteristics; a target audience, introductory material, a series of steps were listed for one or more activities, suggestions for assessments, and the page provided a list of reference materials. Finally, each Web page was visually analyzed to determine if it contained factual or conceptual inaccuracies (i.e. alternative conceptions or misconceptions, Smith, diSessa, & Roschelle, 1993; Wandersee, Mintzes, & Novak, 1994.)

The target audience for each Web page was determined in one of three ways. In many cases, a lesson plan or activity was presented specifying the grade levels for which it was most appropriate. If a particular grade level was not explicitly listed, the home page of that particular Web site was examined for information regarding the target audience. Finally, if neither of these methods provided information about the target audience, but the Web page was clearly targeted to students, then the material was classified as applicable to K - 12 students. We do not feel that the latter method significantly biased the data because the material from these pages was, in most cases, extremely general and could easily be used by students and/or teachers in K - 12 classrooms.

Results

The Altavista search for "Bernoulli's Principle lesson" returned 175 Web page matches. The HotBot search for the exact phrase “Bernoulli’s Principle” returned a total of 408 accessible Web page matches. The HotBot search results actually listed a total of 588 matches, but there were only 408 pages present within the resulting list of pages generated. HotBot technical support was contacted regarding this problem via email. The glitch was apparently due to a problem with the database (Inktomi) that HotBot uses. As of December 1998, this problem was being investigated and remedied (pers. comm.). The Altavista and HotBot searches referenced a combined total of 583 Web pages that were systematically examined for Web-based material that would be of use to students and/or teachers. Of these 583 Web pages, 176 (30%) contained at least a short operational definition or graphic display of Bernoulli's Principle. The data presented in this study are based on these 176 Web pages.

During the initial search for Web-based materials on Bernoulli's Principle, it became apparent that the HotBot search engine was case-sensitive. A systematic investigation of this phenomena revealed that, for 4 out of 9 search engines, capitalizing the phrase "Bernoulli's Principle" in different ways produced a different number of Web records (Table 1).

Search Engine	**Bernoulli's Principle**	**Bernoulli's Principle**	**Bernoulli's principle**	**bernoulli's principle**
Yahoo	257	257	257	257
Excite	295	295	295	295
Netscape	295	295	295	295
Lycos	106	106	106	106
Infoseek	189	189	189	189
HotBot *	269	269	477	487
Altavista *	429	429	760	784
Looksmart *	429	429	760	784
Snap *	200	200	340	351

Table 1. Number of Web page matches for different Internet search engines when searching for the exact phrase "Bernoulli's Principle" capitalized in four different ways. Search performed on October 21st, 1998.

* Search engines that produced different results depending on the capitalization scheme of the input phrase.

The format for presenting material on Bernoulli's Principle differed between Web pages. Fifty-four percent of the Web pages contained only text; while 42% of the Web pages contained text and supplementary graphics. The use of "novel" computer-based media (video and simulations) was relatively rare. Two percent of the Web pages contained QuickTime movies, 1% contained downloadable computer simulation programs, and another 1% incorporated the use of commercial software.

Thirty-five percent of the pages were targeted to the general public. These pages typically lacked an educational focus and simply presented and discussed material on a specific topic. A small number of other pages (3%) were targeted to specialized audiences such as military personal and pilots. The remaining pages (62%) had an educational basis and could potentially serve as reference materials for students and/or teachers (N=109). Thirty-six of these Web pages would be useful resources for

Kindergarten through 6th grade, 28 pages for 6th through 9th grade, 19 pages for 9th through 12th grade, and 17 pages would be applicable to students and teachers in higher education. Furthermore, 39 of these educationally targeted Web pages (N=109) contained a lesson plan for demonstrating Bernoulli's Principle.

The main topic being addressed on each of the referenced Web pages was Bernoulli's Principle itself (50%). Bernoulli's Principle was also presented within resources or lessons on the origin of lift for airplane flight (18%) and within general information on various aviation topics (14%). The main topics of the remaining Web pages included fluid mechanics (4%), tornadoes (2%), the physics of baseball (1%), the physics of Frisbee flight (1%), and other topics (10%).

The content area within which Bernoulli's Principle was addressed also varied. The two most common areas were aeronautics (45%) and physics (34%). Other content areas included sports (5%), science (5%), weather (3%), aerodynamics (3%) and other areas (5%).

The majority of Web pages within the database did not specify a mechanism for providing feedback or communicating with the authors of the Web page (74%). With regards to pages that did provide a feedback mechanism, the most common type available was email (14%). The other means available included submitting a form (2%), Bulletin Board posting (1%), and a telephone number (1%). The remaining pages (8%) did not have a mechanism for feedback listed on the referenced Web page, but had some form of feedback (typically email) available from the home page for that particular page.

Visual analysis of the Web pages in the database revealed a common misconception about the relationship between Bernoulli's principle and the lifting forces acting on an airplane wing. Several of the Web pages explain the lower pressure above the wing using the following argument. First, the air traveling over the top of the wing has a longer distance to travel than does the air traveling under the wing. Second, the air particles that begin together at the leading edge of the wing have to reencounter each other behind the wing. Therefore, the air traveling over the top has to move faster in order to "keep up" with the air traveling underneath the wing and reach the opposite end at the same time. This explanation is inaccurate because there is no physical law associated with this phenomenon (Smith, 1972; Weltner, 1990a, 1990b). In addition, the force of lift on an airplane wing is produced by a combination of forces due to Bernoulli's Principle and Newton's Laws (Smith, 1972; Weltner, 1990a, 1990b; Wegener, 1986).

This misconception, we will refer to as the time-misconception, was present in 19% of the Web sites within the database. Furthermore, this misconception was present in 23% of the lesson plans (n=39). The prevalence of the time-misconception is presented within the context of the sources from which the Web pages originated (Figure 1).

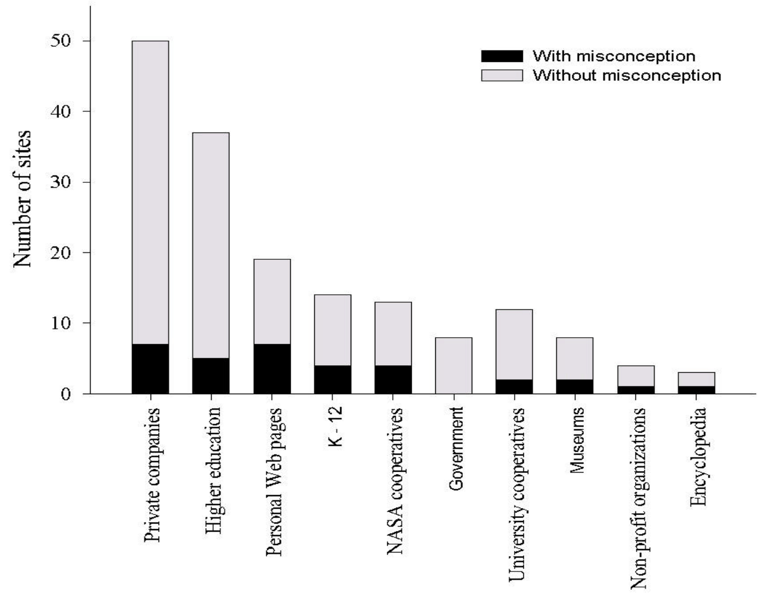

Figure 1. The number of Web-based resources pertaining to Bernoulli's principle originating from various sources (dark bars) and the number of these Web sites that contained the time-misconception (light bars). HotBot and AltaVista searches referenced a total of 583 Web pages that were examined for Web based material that would be of use to either teachers or students. A total of 176 (30%) Web sites contained "useful" information on Bernoulli's Principle.

We discovered a number of the originally sampled sites were no longer accessible during our reanalysis of the database to identify the presence of misconceptions. Our investigation into the presence of this misconception began several weeks after the database had initially been analyzed. Analysis of the referenced Web pages was performed primarily between the second search date (October 13th, 1998) and November 5th, 1998) However, our search for the time-misconception began on December 1st, 1998). Within this short period of time (four weeks), 5% of the pages referenced in the database had gone extinct. Either the address for a particular page had changed or the page had been permanently eliminated, displaying "Error 404 Document Not Found."

Discussion

This study is a first attempt to systematically examine curricular resources on the Web. The Web, when viewed as a giant database, presents a unique opportunity for research. One can quickly and easily query the Web with the use of commercial search engines, each of which has unique properties and characteristics (Chu & Rosenthal, 1996). Our results represent an initial attempt to determine the quantity and qualities of information on the Web relevant to a prevalent and easily searched science concept. We feel that this kind of descriptive study is of particular significance given the early stage of the Web's development in educational settings. Furthermore, this project is part of a longitudinal study of the Web's evolution as a diffusion site for science curricular materials.

The Web is an impressive tool for collecting a variety of ideas on how to demonstrate a particular science concept. We were able to identify over 80 different ways to demonstrate Bernoulli's Principle from our Web search. However, it took dozens of hours to assemble this comprehensive list of demonstrations and lesson plans. Furthermore, the unevenness of the quality of the materials greatly detracts from using the large area search strategy employed in this study on a practical basis.

Web search engines display considerable variation in their search capabilities (Chu and Rosenthal, 1996; Lawrence and Giles, 1998). We were surprised to discover the dramatic effect that different capitalization of our search phrase had on the results generated by several of the search engines. Often the ability of search engines to be case specific is viewed as a benefit to the user (Chu & Rosenthal, 1996). However, our results demonstrate that case specificity may serve to inadvertently screen out potentially useful sites. To some, this may seem commonsensical; however, we suggest that most students and teachers are not aware of the inherent search features within each particular search engine.

The overwhelming majority of the Web pages we examined presented information in the familiar text format, similar to books and magazines. In fact, the majority of these Web pages appear to be composed of information from texts that has simply been transferred to the Web environment. A number of the pages did contain graphics, but very few of the sites capitalized on the unique attributes and opportunities afforded by the Web. For example, video-based demonstrations of science concepts can be a very effective tool on the Web. However, we found only three Web pages that incorporated video to explain Bernoulli’s Principle.

Another unique type of Web-based resource is the use of computer simulations. Computer simulations were present within less than two percent of the Web sites that contained information on Bernoulli's Principle. Three out of the four Web sites that relied on computer simulation were from Microsoft (http://www.eu.microsoft.com/games/ fsim/tag/prinflight_lesson.htm). These sites provided lesson plans and activities to be used with their commercial Flight Simulator program. A second simulation-based Web site contained a downloadable simulation program, FoilSim. This program does an exemplary job of presenting the concept of Bernoulli’ Principle in the context of a simulated airfoil and a simulated baseball in flight. Initially, we were unable to locate lesson plans or activities associated with this simulation. However, further exploration of the Web using the search term "foilsim" revealed a page that provided an extensive description and set of lesson plans related to the FoilSim program (http://www.lerc.nasa.gov/WWW/K-12/aerosim).

The paucity of video and simulations on Web sites featuring Bernoulli's Principle is probably due to the limitations of the hardware and slow dial-up connections available to most K-12 educators. In the last three years there has been a trend toward schools connecting to the Internet via higher speed dedicated lines (National Center for Education Statistics, 1999). The percent of public schools connecting the Internet by dedicated line has increased from 39% in 1996 to 65% in 1998. As this trend continues, we expect to see a corresponding increase in the sophistication of Web-based materials made available to science educators.

The trend toward an increasing number of educators gaining access to the Web and using it as a source of classroom materials may bring new problems as well as the obvious benefits. Our data offer a relatively comprehensive view of the resources available pertaining to Bernoulli's Principle as a particular physical science concept. A large number of the Web pages were targeted to teachers and/or students. All grade levels were represented, with a greater number of resources targeted towards elementary versus high school or higher education. Many of these resources included lesson plans that contained various activities or demonstrations. This is not surprising due to the central role that lesson plans and activities play in the classroom and the inability of many teachers to find time to develop their own activities. However, an examination of the Web pages in our database revealed that one of the biggest problems with Web-based resources is that many of the lesson plans and demos lacked the complexity and depth of content found in the older (pre-1980) print materials surveyed for this study. The typical Web site with an associated lesson plan on Bernoulli's Principle exhibits a "less is more" philosophy, often at the expense of content. One notable exception is the site entitled "Bernoulli Brain-Teasers" from the National Air and Space Museum (http://www.nasm.edu/GALLERIES/GAL109/LESSONS/TEXT/TEASERS.HTM). This site offers a multi-level approach to explaining the principle Similarly, a site developed by the National Teacher Training Institute offers excellent lesson plans (http://192.156.97.132/kn/itv/lift.sht).

The dynamic characteristics of a Web site allow for continual change and updating of content. Therefore, the ability to provide feedback to a Web site can play a central role in the development and evolution of the Web and the quality of the materials that are featured in these Web sites. Despite this potential for interactivity, we found very few sites that provided the user with the opportunity to provide feedback or ask questions regarding the material featured in Web pages. The ability to inquire about the information presented in a Web site should be of primary importance, especially within educationally based sites. We envision the power of the Web will be realized when feedback mechanisms commonly allow for materials to be elaborated and refined through time.

The most disturbing finding of this study was the identification of a common misconception in the application of Bernoulli's Principle to the concept of lift in a significant number of science education Web-sites. What we have called the "time misconception", originated in the print-based materials and has diffused and multiplied in the Web environment.

A larger goal of our research program is to develop a model that can be used to characterize the diffusion of education curricular materials on the Web (Keating, MaKinster, & Beghetto, in preparation). The emerging field of Memetics offers a promising approach to describing the diffusion of ideas and artifacts in the Web environment. Memes were originally proposed by the evolutionary biologist Richard Dawkins' in the last chapter his book, The Selfish Gene (Dawkins, 1989). Dawkins describes memes as a new class of replicator, or unit of imitation, that serves as a unit of cultural transmission. Much in the same way that genes are replicated, transmitted to ensuing generations, and subject to selection pressures from the environment, memes evolve through a process of Darwinian natural selection. Memes can be, ideas, catch phrases, clothes fashions, scientific theories, religions, musical styles or the use of gadgets (Dawkins, 1989; Heyligen, 1996).

The concept of a meme remains somewhat controversial due to the difficulty and imprecision of defining a meme in cultural or cognitive terms (see, for example, Polchak, 1998). However, using memetics to examine tangible artifacts, such as curricular resources, may avoid many of the problems associated with memes. Curricular resources exist as documented ideas, concepts and other artifacts. This condition provides a tangible framework to examine their diffusion and evolution. Dennett (1995) outlines three conditions that must be met for Darwinian evolution to occur:

> (1). Variation: there is a continuing abundance of different elements
>
> (2). Heredity or replication: the elements have the capacity to create copies or replicas of themselves
>
> (3). Differential "fitness": the number of copies of an element that are created in a given time varies, depending on interactions between the features of that element and features of the environment in which it persists (page 343).

The Web-based curricular resources featured in this study meet the three conditions for evolution stated above. First, the prevalence of demonstrations and diagrams of Bernoulli's Principle displayed dramatic variation. Our search of the Web turned up 83 different ways to demonstrate Bernoulli's Principle (see Table 2 for a consolidated list of classic demonstrations).

Demonstration	**Number**
Blowing between objects	25
Blowing across paper	24
Airstream with balls	24
Spool and card	12
Floating in a funnel	9
Atomizer	8
Paper airplanes	7
Leaping coins	5
Hand out of car	5
Throwing a ball	4
Blowing the bridge	4
Airstream with bubbles	3

Table 2. Number of classic demonstrations present within Internet sites containing curricular material on Bernoulli’s Principle (N = 176). A single site may have described anywhere from zero to 15 demonstrations (avg. = 1.59).

Second, diagrams, lesson plans and demonstrations exhibit patterns of replication within and between print materials and the Web environment (Figure 2). The persistence and diffusion of the time misconception from print materials to the Web environment is a dramatic example of virus-like behavior of certain memes. Third, demonstrations of Bernoulli's Principle, and the Web-sites themselves, exhibited differential fitness. Three demonstrations, blowing across a sheet of paper (n=24), Ping-Pong ball in an air stream (n=14), and blowing through a spool to suspend a card (n=12), accounted for 41% of the total number of demonstrations present in our database. Forty-four percent of the demonstrations were unique applications of Bernoulli's Principle. The Web-sites we sampled for this study displayed a high rate of extinction. Five percent of the sites were no longer accessible after a one-month period. Based on these observations, we are led to hypothesize that the demonstrations that replicate and diffuse are those that require the simplest explanations with the cheapest and most readily available materials. We present the details of the application of this model in a separate paper (Keating, et al., in preparation).

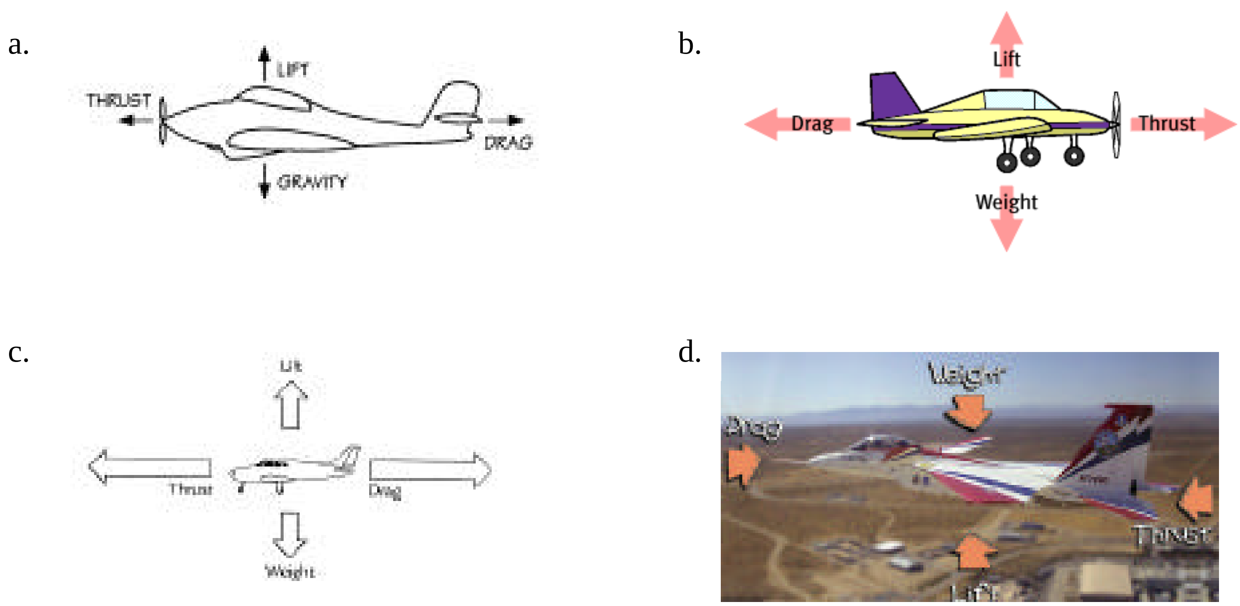

Figure 2. Graphical representations of the various forces acting on a plane during flight. Images were originally used in the context of explaining how Bernoulli's Principle explains a portion of the lifting force on an airplane wing. a. From an elementary sourcebook of activities and demonstrations (Bosak and Puppa, 1991). b. From 3 different WWW sites (http://nasaui.ited.uidaho.edu/nasaspark/fly.htm; http://quest.arc.nasa.gov/aero/teachers/foa.html; http://198.123.15.250/aero/teachers/foa.html). c. From the PlaneMath.com WWW site (http://www.planemath.com/activities/pmenterprises/forces/forces1.html) d. From the WWW site for Yes Mag: the Canadian Science Magazine for Kids (http://www.yesmag.bc.ca/focus/flight/ flight_science.html).

In this paper we have set out to document the cyber-history of Bernoulli's Principle on the Web. In so doing, we were able to describe the richness and variation of the curricular materials associated with Bernoulli's principle. However, at this early stage in the evolution of the Web as a repository for curricular materials, it is extremely difficult and time consuming to compile these resources for classroom use. Furthermore, the Web has the capacity to be "infected" by science misconceptions and to propagate the misconceptions to a global audience. Future studies will attempt to document and study the presence and diffusion of Web-based alternative conceptions, diagrams and demonstrations associated with Bernoulli's Principle. We must begin to examine not only how teachers are using Web-based resources, but also consider the nature of these resources and how they contribute to student understanding.

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