Real-World Instruction and the World Wide Web:
How WeatherBug Achieve Improves Student Performance
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1. Executive Summary

If K-12 education is to flourish in the United States, educators and administrators must ask the tough questions and be accountable for both the processes and products that emanate from the classroom. This paper defines the benefits of a web-based program that utilizes real-time, real-world data to create an educational atmosphere of discovery and inquiry through the lens of research validating these components as drivers of improved student performance.

Research references include, among others:

1. Meta approaches to instructional efficacy by aggregating findings from 100+ studies by Robert Marzano (Marzano, 1998);
3. A study of the instructional efficacy of web-based technology in the classroom by S. A. Barab and A. L. Luehman (Barab & Luehman, 2003); and

Following are the key conclusions drawn from the research reviewed that are directly mapped to the features and content in WeatherBug Achieve:

- The average student who utilized learning techniques identical to those included in Achieve outscored more than 84% of students in the control group (Cholmsky, 2003).

- Given proper implementation, the web-based medium had significant positive effects on student participants (Mouza & Bell, 2001)

- Learning via computer simulations is closely correlated to more progressive, thoroughly proven pedagogy.

- The classroom setting must be flexible enough to utilize technology in an engaging, active environment that supports the nuances and needs of local cultures. A static, generic pedagogy does not beget motivated learners. The authors reflect on several weather-based, inquiry-focused settings like those upon which WeatherBug Achieve is founded (Barab and Luehman, 2003).

- Children from diverse backgrounds and diverse educational settings were able to draw from real world settings like those in WeatherBug Achieve rather than digest the traditional domains of science that are less personally engaging and often not sociologically correlated, moreover relevant (Papierno, Makel, & Ceci, 2004).

- Reasoning from data distinguishes scientific reasoning from logical reasoning (Masnick and Morris, 2002). As reasoning and inquiry are critical to the instructional mission of science and math, if not all, disciplines, Achieve’s web-based format allows for pedagogical and intrinsic motivation otherwise not utilized or attained.
II. Company Overview & History

AWS, WeatherBug’s parent company, operates a network of over 7,000 school-based weather stations and 1,000 weather cameras. It is the largest weather network in the world, and it is used by tens of millions of households, businesses, government agencies and schools every day.

The WeatherBug suite of products and services include those for the consumer (WeatherBug, WeatherBug Plus, and WeatherBug Media Services), K-12 and post-secondary education (WeatherBug Achieve and WeatherBug Online Weather Center), and business products (WeatherBug Professional). All are based on the proprietary network of WeatherBug Tracking Stations and cameras.

Founded in 1992, the Company was created by two engineers with close ties to K-12 education and launched as the “School WeatherNet Program”; shortly thereafter, the company developed WeatherNet services for media broadcasters. In 2000, AWS created the WeatherBug desktop application, providing Internet users access to live (up to the second), neighborhood weather data that had never been available to the general public. After more than a decade of service to education, government, media, and the general public, with a user base of more than 20 million, WeatherBug has evolved into a top Internet property and a brand that is felt across multiple industries, across all 50 states, Canada, and the Caribbean. In further boosting its national prominence, WeatherBug has established relationships with the National Oceanic and Atmospheric Administration’s National Weather Service (NWS) and the Department of Homeland Security (DHS).

In April 2004, after ~12 years of K-12 relations, AWS released its newest web-based education program, WeatherBug Achieve. As of October 2004, Achieve has over 1,300 subscriptions and ~5,000 teachers.

III. NCLB and SBR Requirements

A. NCLB:

In Spring 2002, the 107th U.S. Congress enacted a revision of the Elementary and Secondary Act (ESEA), entitled the No Child Left Behind Act of 2001 (NCLB). One of the major provisions under NCLB was the increased requirement of scientifically based research (SBR) to validate the effectiveness of products and services in K-12 education. Since NCLB’s enactment, education technology and service companies have released a myriad of research findings to substantiate their products and services. Unfortunately, not all purported SBR is equally relevant, valid, or reliable, and not all technology is a solution to the hurdles put forth in NCLB.
B. SBR Requirements:
*Under NCLB, scientifically based research must:*

- Employ systematic, empirical methods that draw on observation or experiment;
- Involve data analyses that are adequate to test the stated hypotheses and justify the general conclusions drawn;
- Rely on measurements or observational methods that provide reliable and valid data across evaluators and observers, across multiple measurements and observations, and across studies by the same or different investigators;
- Be evaluated using experimental or quasi-experimental designs in which individuals, entities, programs, or activities are assigned to different conditions and with appropriate controls to evaluate the effects of the condition of interest, with a preference for random-assignment experiments, or other designs to the extent that those designs contain within-condition or across condition controls;
- Ensure that experimental studies are presented in sufficient detail and clarity to allow for replication or, at a minimum, offer the opportunity to build systematically on their findings; and has been accepted by a peer-reviewed journal or approved by a panel of independent experts through a comparably rigorous, objective, and scientific review (NCLB, 2002).

The studies referenced in this whitepaper meet the above conditions for SBR as outlined in NCLB and are valid for assessing Achieve’s impact on student outcomes.

C. Research Validation of WeatherBug Achieve:

The studies represented herein validate the efficacy of Achieve in three areas: instruction, real-world data, and standards correlation.

1. Instructional Efficacy and Achieve


Robert Marzano is one researcher who takes a global or meta approach to instructional efficacy and analysis (Marzano, 1998). Marzano, by aggregating findings from 100+ studies, describes instructional efficacy in four ways (see Exhibit 1). Superior instructional efficacy must:

1. represent new knowledge in graphic, non-linguistic formats;
2. generate and test hypotheses about new knowledge;
3. teach new knowledge to students directly through demonstration and explanation and have them independently apply the learning in a variety of contexts; and
4. use computer-based manipulatives or tools for exploration and practice of new knowledge.

Marzano found these four instructional techniques as having the greatest effect across all the 100+ studies; in other words, the average student who utilized these techniques outscored more than 84% of students in the control group (Cholmsky, 2003).
Exhibit 1.
Marzano’s Effective Instructional Techniques (Cholmsky, 2003)

Achieve satisfies Marzano’s metrics in the following four ways:

- **Achieve** represents new knowledge in graphic, non-linguistic formats through its multifaceted use of live camera images from over 1,000 WeatherBug weather stations with cameras as well as the map gallery included within its “Tools” menu;

- **Achieve** generates and tests hypotheses about new knowledge through its interactive lessons and integration of live weather data and images;

- **Achieve** teaches new knowledge to students directly through demonstration and explanation and has them independently apply the learning in a variety of contexts through observation of the same environmental settings using over 1,000 WeatherBug cameras and 27 weather attributes in over 7,000 locations that, through repetitive aggregation and analysis, renew the concept by changing the information each time the sources are accessed;

- **Achieve** uses computer-based manipulatives or tools for exploration and practice of new knowledge through the following easy-to-use tools:
  - Weather observations, (see Exhibit 2)
  - WeatherBug Cameras, (see Exhibit 2)
  - Map Gallery, (see Exhibit 3)
  - Storm Central,
  - Weather Summaries,
  - Storm Display,
  - Change Tracking Station,
  - Change Camera, and
  - The Lewis and Clark Weather Portal.

www.weatherbugachieve.com
Exhibits 2 and 3

The WeatherBug DataCam and Map Gallery tools afford students the opportunity to observe first-hand the direct correlation between changes in environmental conditions and changes in data gathered, all through graphic, non-linguistic formats.

b. Mouza and Bell (2001)

Instructional efficacy is derived through teachers who utilize multifaceted pedagogies to motivate students and create a zeal for learning that carries them through all years of the K-12 school system. The visual, auditory, and kinesthetic modalities must all be “touched” if every student is to attain the gifts of knowledge and reasoning. When implemented correctly, moreover seamlessly into the existing classroom culture, the web-based medium is proven to be very effective (Mouza & Bell, 2001).

At Teachers College, Columbia University and Lockheed Martin Advanced Technology Laboratories, Mouza and Bell (2001), respectively, used a web-based science project (ALPINE) to teach the fundamentals of weather, data gathering and processing techniques, decision-making, and problem-solving (pg. 265).

Six teachers and 126 students participated in the study in a mid-sized suburban New Jersey school in an all fifth grade setting. The study evinced no statistically proven significant impact on students and teachers. However, the study profoundly states that, given proper implementation, the web-based medium had significant positive effects on the student participants, an effect that the statistical outcome could not relay. Observational and interview data clearly indicate significant positive effects on students. By taking most of the teacher participants from a traditional to a more progressive or constructivist pedagogy, the medium acted as a bonus instructional tool.

The Mouza and Bell study was influenced by an instructional theory titled Anchored Instruction, a concept of Peabody College, Vanderbilt University, and denotes the anchoring of meaningful instruction to acquire knowledge to be used rather than stored away and forgotten (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). The main takeaway from the Mouza and Bell study is that learning via computer simulations is closely correlated to more progressive, thoroughly proven pedagogy.

Barab and Luehman (2003) further prove the instructional efficacy of technology in terms of its implementation and adoption into a local setting. The classroom setting must be flexible enough to utilize technology in an engaging, active environment that supports the nuances and needs of local cultures. A static, generic pedagogy does not beget motivated learners. The authors reflect on several weather-based, inquiry-focused settings.

Three of the many project-based curricula cited in the study are worth mention herein. Global Learning and Observations to Benefit the Environment (GLOBE) is a hands-on science program used in nearly 5,000 schools from over 60 countries where students collect real-world data and post results on the World Wide Web. The aggregated data is used to generate visual products (displays, maps, etc.). Nine years of research using the Kids as Global Scientists Weather (KGS) Program portrays broad instructional efficacy using web-based technology in the classroom (Songer, Hartman, & McDonald in Barab & Luehman, 2003). KGS connects students from around the world and incites inquiry by producing weather specialists who interact and dispute the reports and following global predictions. Two decades of research pay tribute to “the flexibly adaptive character of the Web-Based Inquiry Science Environment (WISE) project [that] supports local customization as one means to help teachers build sustainable science instruction” (Linn, Clark, & Slotta in Barab & Luehman, 2003, pp. 456). Web-based, real world data aggregation and analysis in a localized setting that induces visualization and deep learning align with Marzano’s (1998) theory of instructional efficacy.

The main takeaway from Barab and Luehman’s study is that there is no one-size-fits-all pedagogy for K-12 education. All of the above projects are founded in project-based, inquiry-focused learning that is seamlessly added to the science curriculum.

Luehman (2002) declares that the task of customization and local adaptation must:

- Identify local needs;
- Critique the innovation in light of these needs;
- Visualize possible scenarios of implementation; and
- Make plans or decisions regarding the implementation.

Barab and Luehman (2003) highlight the following formula for the local adoption, customization process:

**Teachers’ Perceptions + Designed Curriculum + Classroom Culture = Implemented Experience**

As Achieve teachers customize their curricula and pedagogy to make WeatherBug data access an everyday occurrence, they realize the positive correlation between Achieve’s real-world, real-time engine and an existing, more traditional, core text-based pedagogy.

WeatherBug Achieve supports the same line of thinking. With real-time access to weather data across more than 7,000 sites, it would be impossible to create a static classroom environment. As teachers see the positive benefits of Achieve and infuse it into existing culture, they have taken a positive step toward ensuring motivated, inquiry-based students ask divergent questions of themselves and others. Take, for example, Achieve’s Investigating Barometric Pressure lesson.
Example #1: Investigating Barometric Pressure Lesson

Exhibit 4.

The lesson is targeted to grades 6-7 and discusses the impact of barometric pressure on the weather. The lesson has three objectives:

- To define barometric pressure.
- To determine how barometric pressure is measured.
- To interpret barometric pressure data.

It uses historical weather from the preceding three days to walk the student through the scientific method of investigation.

Exhibit 5.

After gleaning a short explanation of barometric pressure and English and Metric measurement units, the student is asked to analyze weather from a table with historical data. Barometric pressure is part of that table – along with other data such as wind speed, temperature, rainfall and more. The student is encouraged to come up with hypotheses on possible connections between and among these weather attributes.
Exhibit 6.

Next, the barometric pressure parameter is isolated into a line graph. Herein, the student tracks the behavior of this parameter.

Exhibit 7.

Finally, the student is presented with a two-line graph that contains the barometric pressure and rainfall values for the preceding two days. Is there a connection? The student is encouraged to use the graph tool and analyze other weather values using the same method.

In this lesson – as with many other lessons in Achieve, the individualized weather promotes scientific hypothesis. In this process, one piece of the known, real-world is isolated and quantified. (barometric pressure)

The student recalls the weather in the last few days as he remembers it and builds testable hypotheses. (It was really windy in the last few days and the graph shows that the barometric pressure went down. Maybe wind blows into areas with low barometric pressure.)
The student can further investigate the hypotheses by analyzing other areas that are windy. Going to “Extreme Weather” under “Library” in the navigation menu presents a table with locations in the WeatherBug network that have recorded extreme weather data. The table presents locations with highest and lowest temperatures, high rainfall, and high winds.

Consistently and reliably, the web-based format of Achieve gives real-time access to over 100 lessons that cover science, math, and geography and are correlated to state standards. Educators who utilize the online or computer-based mediums often shift from traditional methodology to a more constructivist teaching process, one that links new knowledge with prior knowledge.

2. Real-World Data, Metacognition, Inclusion, and Achieve

As highlighted through examples above, Achieve is unique and scientifically relevant in its application of local, proprietary weather data. Through the consistent and discovery-laden use of this real-world data, Achieve incites inquiry and metacognition in each user.


The knowledge of prior experiences and self-awareness of ongoing cognitive processes have been of major interest to Williams, Papierno, Makel, & Ceci (2004) at the Cornell Institute for Research on Children (CIRC). CIRC, inspired largely by the Practical Intelligence for School Project (PIFS), finds that “scientific reasoning might also be amenable to metacognitive induction” (Williams et al., 2004).

This two-year CIRC study emphasized five sources of metacognitive development:

1. knowing why,
2. knowing self,
3. knowing differences,
4. knowing process, and
5. revisiting.

Results showed that children from diverse backgrounds and diverse educational settings were enhanced through the CIRC metacognitive study as they were able to draw from real world settings rather than digest the traditional domains of science that are less personally engaging and often not sociologically correlated, moreover relevant. These results merely underline the importance of cognitive and metacognitive experiences in promoting both intrinsic and extrinsic motivation in diverse K-12 environs. They further highlight the fact that Achieve’s broad and deep content base and interactive interface incite the above five sources of metacognitive development.
Example #2: Achieve Map Gallery Tool

Achieve’s Map Gallery is a unique tool that combines real-time maps, weather data and a drawing tool that the student can use to represent her conclusions. The layers appear in the tool-like transparencies. One can replace a layer without affecting the others.

Exhibit 8: Real World Visualization & Metacognition

Layer 1: Physical map
The physical map provides data on the location of U.S. cities and their current temperature and elevation. There are underlying regional and sub-regional layers that allow the student to drill down to individual states.

Layer 2: Weather Data
The student can present 15 different weather observations per city on the map.

Layer 3: Radar and Satellite Images
The student can present the radar map (precipitation), satellite infrared (upper atmosphere temperature) and a satellite visibility map (cloud coverage). The student can observe this visual data over time by generating three hour loops for each map.

Layer 4: Interactive Layer
The student can draw on this layer and apply stamps from symbol libraries.

Projects that use the Map Gallery tool naturally fuse the student’s prior weather experience with its data representation. The “knowing self” (Williams et al., 2004) aspect of metacognition becomes the main catalyst for decoding visual and alpha-numeric data within a familiar context.
Following a weather system, both through the use of an Achieve tool and her observations outside the window, adds a time-track to the process. The student can compare two static weather instances and explain how the system evolves. The comparison also ameliorates decoding of visual and alpha-numeric data. (Two hours ago it was raining here and our city was covered with green in the radar image. Now, it’s not raining and the green disappeared.)

The rich set of data, the personal weather experience, and the capability to compare while tracking a weather event over time all provide an optimal basis for addressing the divergent why questions.

The most important advantage of Achieve herein is its foundation for prompting the “why” question in a scientific method: Why are certain areas affected by the hurricane, whereas others are not? Why does the air pressure go down in areas near the storm?

Example #3: Camera & Graph Tool

The Camera and Graph tool matches photographs and alphanumeric weather data, represented in a line graph.

Exhibit 9:

Camera and Graph Tool – Hurricane Frances

The tool enables the student to move back and forth in a sequence of a time-lapsed photographs and compare the observed weather as seen in the photograph with data represented in the graph. The student can track and compare up to two weather parameters with the camera loop.

In the example above, the student follows the development of the storm through the photographs (High winds create high waves that will cover greater areas of the shore) and the graph.
comparing the wind speed and the pressure values, the student sees that the pressure decreases while the wind speed increases. The comparative conclusion, that air moves from areas of high to low pressure, is self-induced via an easily navigable camera and graph tool.

*WeatherBug Achieve takes a large scale weather event such as a hurricane and brings it to the desktop. Students can examine events through photographs, maps, weather data, and graphs. The same can be conducted for everyday weather occurrences.*

b. Kanari and Miller (2004); Masnick and Morris (2002)
Kanari and Miller (2004) explored the student cognition disseminating from data and the ways in which students reason from this same data. They discovered that the larger the data set, the more likely a student was to reason and know the content. A study by Masnick and Morris (2002) accentuates the depth and relevance of an over 7,000 station data set, one that makes for very reliable data, data that induces profound reasoning via the interactive, web-based Achieve interface. The study relays the direct correlation between sample size and validity of outcome. A middle or high school teacher can easily track weather, severe or otherwise, from the time it hits the borders of the U.S. to the point where it passes overhead. The implications herein are not only real but perhaps even life saving. As stated in Masnick and Morris (2002), “it is reasoning from data that distinguishes scientific reasoning from logical reasoning” (pg. 765). As reasoning and inquiry are critical to the instructional mission of science and math, if not all, disciplines, Achieve’s web-based format allows for pedagogical and intrinsic motivation otherwise not utilized or attained.

3. Standards Correlation, Technology, and Achieve

One study, (Irving & Bell, 2004), asserts the relevance of education technology in support of standards and assessments for math and science. Irving and Bell’s study is a qualitative reminder of national standards and an examination of the role of technology in achieving compliance of the same through analyses of three national standards:

- Standards 2000 (NCTM, 2000);
- National Science Education Standards or NSES (NRC, 1996); and
- National Educational Technology Standards or NETS (ISTE, 2000).

Also examined were the following national secondary assessments:

- SAT I & II;
- ACT;
- AP; and
- Praxis Series.

Technology is found to influence both how math and science are taught and the choice and sequencing of math and science topics. However, there are profound differences in the way national standards define and endorse technology.

NCTM’s Standards 2000 is descriptive in its definition and segmentation of technology validity in the math classroom. These standards identify five content and five process standards, 8 of these 10 explicitly refer to instructional technology, its application and importance to math instruction (see Tables I and II from Irving and Bell, 2004, pgs. 258 and 259).
Conversely, NSES has a very broad definition of technology. While NSES has six general areas of interest in its science standards, it has no marker for technology within this spectrum. As Irving and Bell aptly impart, “[f]or science educators searching for a vision of appropriate uses of educational technology in science teaching, the NSES fail to deliver” (2004).

Fortunately, ISTE in NETS is very clear about what students should know and be able to do by grade level for each discipline except foreign language. In science, NETS impart technological application and progression with two sample lessons at each grade level. For example, in grades 3-5, NETS endorses a World Wide Weather lesson that encompasses the use of the Internet, presentation software, and e-mail.

Although Achieve is aligned to both state and national standards, NCLB has no mandate for web-based learning. However, individual states do require information technology skills. One might beg the overriding question as to the place, moreover the declaration for the Web in the classroom. President Bush’s recent proposal as part of an extension to NCLB for an eLearning Clearinghouse at the very least acknowledges the importance of the online medium as a viable if not nationally required instructional tool if not skill set for K-12 education and life thereafter.

IV. Conclusion

If K-12 education is to flourish in the United States, educators and administrators must ask the tough questions and be accountable for both the processes and products that emanate from the classroom. This paper defines the benefits of a web-based program that utilizes real-time, real-world data to create an educational atmosphere of discovery and inquiry through the lense of research validating these components as drivers of improved student performance.

Marzano’s meta-analytical criteria for effective instructional techniques are rolled up in Achieve’s easily navigable visual interface; its generative, inquisitive lessons; its real world subject matter, and its exploratory manipulation of proprietary WeatherBug data.

In short, WeatherBug Achieve is a product that meets these criteria alongside state standards in math, science, and geography.

The final bonus in Achieve’s programmatic offerings addresses the civil, more humanistic side of K-12 education. In Achieve’s “Let’s Help” section, students and teachers can lend a helping hand to schools and communities in need because of catastrophic, traumatic weather conditions and, in turn, are doing more than learning. They are applying human qualities in an otherwise scholastic environment. The profound educational psychologist, John Dewey, described it best when he wrote during the Depression that students must have experience but must first have the nature of human experience (Dewey, 1938). Achieve allows students, teachers, administrators, schools, and communities to unite in times of need.

The undeniable value proposition in Achieve is its unlimited access to the largest real-time weather network in the world, supported by quality content and tools to apply and study the same.

The empirical evidence cited in this paper emphatically proves the effectiveness of WeatherBug Achieve’s pedagogy, its real-world application, and correlation to national and state standards. The vehicle is weather, the outcomes are pedagogical tools that hone and enhance metacognitive processes and the long-term retention of critical concepts in learning.
V. References


