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# Workshop Physics: An Activity-Based Curriculum Enhanced by Computer Tools

**Chao Fu, Xiumei Feng***

College of Physical Science and Technology, Central China Normal University, Wuhan, China

**Email address:**
fc_spencer@163.com (Chao Fu), xiumeifeng@mail.ccnu.edu.cn (Xiumei Feng)
*Corresponding author

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**Abstract:** Workshop Physics, initiated by P. W. Laws and her colleagues at Dickinson College, is an activity-based collaborative-learning curriculum enhanced by using computer tools for data acquisition, display and analysis, during which students experience various learning activities including predictions, qualitative observations, quantitative experiments, mathematical modeling and problem solving, etc. The curriculum was formally established when the Workshop Physics team was awarded a two-year grant from the Fund for the Improvement of Postsecondary Science Education. As a more flexible and comprehensive set of activity-based curricular materials were needed, the Activity-Based Physics Suite, which included Workshop Physics, Interactive Lecture Demonstrations, Real-Time Physics, was integrated to reduce implementation barriers for instructors. With the philosophy of reducing content, abandoning formal lectures, emphasizing the process of scientific inquiry and using computer tools flexibly, Workshop Physics centers around *Workshop Physics Activity Guide*, a series of workbooks covering selected content about Mechanics, Thermodynamics and Electromagnetics, along with diverse computer tools, customized apparatus and other supplemental learning materials such as the *Interactive Video Vignettes*. Over years of development, although in need of a few more adjustments and modifications, Workshop Physics has won prestigious reputation among students and instructors for its cooperative learning environment, diverse activities, efficient tools and remarkable teaching effectiveness.

**Keywords:** Workshop Physics, Activity-Based, Computer Tools

## 1. Introduction

The low efficiency of traditional lectures of college physics has been perplexing the physics education community. In order to solve this problem, the American physics education researchers have explored many influential teaching methods in a long-term teaching practice, such as Peer Instruction [1], Physics by Inquiry [2], Tutorials [3], SCALE-UP [4], Interactive Lecture Demonstrations [5] and Workshop Physics [6]. It has been proven that these teaching methods play a remarkable role in increasing class attendance rate, promoting students' interest and concept comprehension in physics. Eventually, these teaching methods created along the way have given birth to a compatible structure entitled the Activity-Based Physics Suite. As one component of the Activity-Based Physics Suite, Workshop Physics (abbreviated as WP), initiated by P. W. Laws and her collaborators at Dickinson College, integrates lectures and laboratory sessions, which remain separated in traditional teaching, together to form an activity-based collaborative learning environment enhanced by computer tools. WP enables students to build their concepts through activities using efficient technology.

How can WP utilize modern technology to create an effective learning setting, prompt students to actively acquire knowledge and realize the improvement of students' physical concepts and inquiry skills? By exploring WP's formation process, teaching philosophy, curriculum organization and resources as well as the feedback of teaching effectiveness, this paper attempts to find the characteristics of WP and provide a valuable reference for today's educational practice.

## 2. Genesis and Development

In 1985, Priscilla Laws began to question how introductory physics should be taught in college after teaching physics at

Dickinson College for 20 years. Once, Laws attended a daylong hands-on workshop on digital electronics during a meeting of the American Association of Physics Teachers (AAPT) and constructed a digital stopwatch through the day's hands-on endeavor with her partner, thinking that they learned more in this eight-hour workshop than they could have in half a semester [7]. Inspired by this incident and the Physics Education Research (PER) [8] findings documenting the ineffectiveness of traditional lecture-based instructional methods [9], Laws and her colleagues Robert Boyle and John Luetzelshwab submitted a proposal to the Fund for the Improvement of Postsecondary Science Education (FIPSE) to develop a new introductory physics program that abandoned the conventional method of separate lectures and labs in favor of a computer-enhanced "workshop" where students in collaborative groups make predictions and observations and then conduct more formal experiments. In fall 1986, Dickinson College was awarded a two-year grant from FIPSE to develop the Workshop Physics curriculum [10], which symbolizes the birth of Workshop Physics.

During its early development, WP was initially adopted at Dickinson College and students who enrolled in the two-semester calculus-based physics sequence at Dickinson in the scholar year of 1986 to 1987 worked with brand-new WP activities along with worksheets completed at the last moment. Back then, Unit 1 in Module 1 of *Workshop Physics Activity Guide* (WPAG, introduced in Chapter 2) focused on data acquisition and spreadsheet use, while Unit 2 introduced Gaussian statistics and measurement uncertainties. As time elapsed, further activities were developed where students conducted experiments and created graphs with a low-friction cart. Next, subsequent activities allowed students to observe real-time graphs of a vertically tossed ball, and activities dealing with mechanics, thermodynamics, electricity and magnetism came about as WP developed and made modifications [10].

After Maxine Willis attended a Technical Education Research Centers (TERC) sponsored workshop at Dickinson, the Workshop Physics curriculum entered Gettysburg Area High school in fall 1989, which marked WP's debut at secondary schools. Maxine ordered 12 Mac SE computers for her honors class who began working with activities in Unit 1. Back then, with no Microcomputer-Based Laboratory (MBL, systems that interface sensors with computer game ports) available, students jumped right ahead to the new unit on "Chaos" and became fascinated with the mathematical power of the computer, showing surprisingly high interest in WP. In 1995, AP Workshop, designed to prepare students for AP Physics and Calculus exams, worked remarkably as students' scores at both exams between 1995 and 2001 improved significantly. In addition, over these years the average normalized gain on Force and Motion Conceptual Evaluation (FMCE) [11] rose to 0.66, which was significantly higher compared to that of traditionally taught courses (0.20) [10].

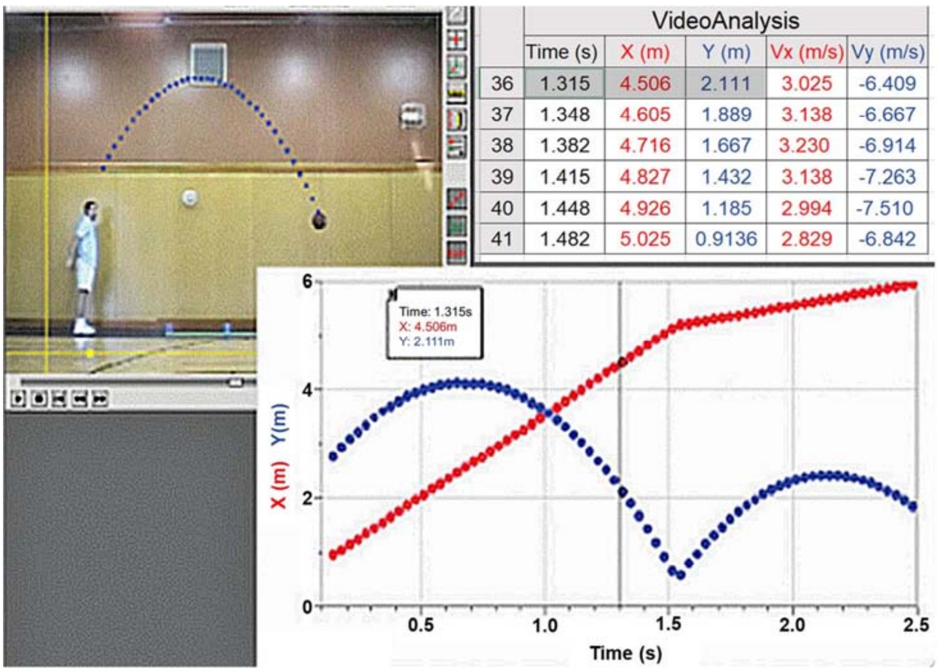


***Figure 1.*** *Logger Pro demonstration [10].*

In order to optimize curriculum resources and learning environment, the WP teaching staff at Dickinson also made other modifications: a) refining existing apparatus and developing new apparatus; b) creating video-analysis software VideoPoint, which had been replaced by Logger Pro (Figure 1) from Vernier Software [12] and Capstone from PASCO scientific [13]; c) redesigning WP instructional space (an 800 square feet workshop room) [10]. All of the above will be introduced with details in Chapter 2.

In the early 1990s, Laws and her team received feedback indicating that a more flexible and comprehensive set of activity-based curricular materials were needed [7]. Hence, they began to work on Interactive Lecture Demonstrations (ILDs) [14] and Real-Time Physics (RTP) [15]. In 1997 and 1998, the Activity-Based Physics (ABP) group and Stuart Johnson began discussing the feasibility of integrating a broad array of PER-based curricular materials to form a "suite", with the major goal of reducing implementation barriers, which should enable instructors to simply apply one part of the suite independently or integrate several elements simultaneously [16]. In 1998, *The Physics Suite*, published by John Wiley & Sons [7], documented the Activity-Based Physics Suite which consisted of ABP curricular materials including WP, ILDs, RTP, etc. A more detailed description of the suite's elements is revealed in Figure 2.

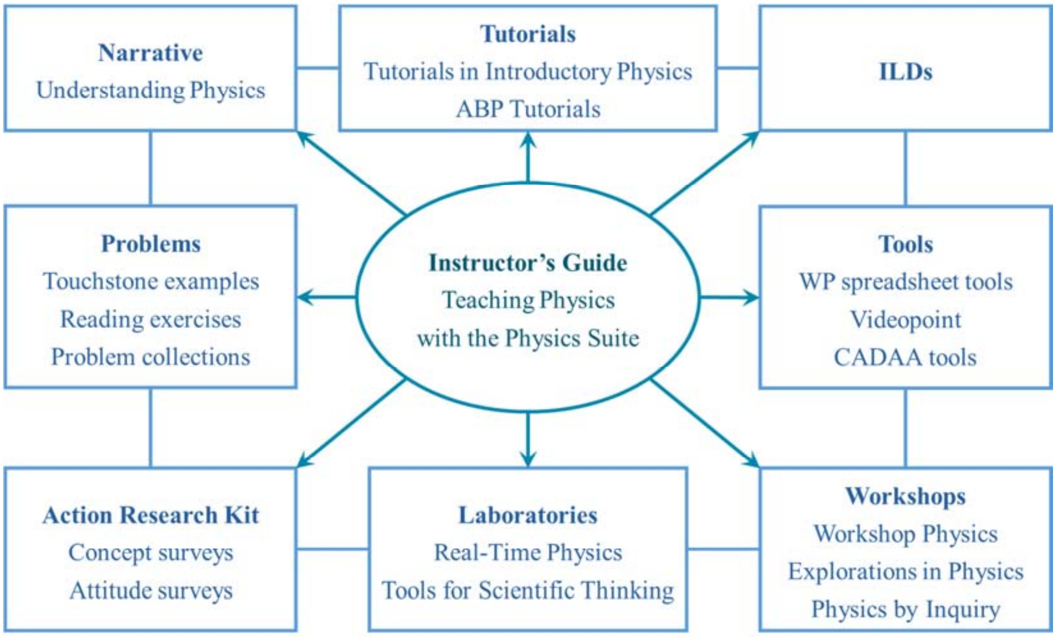


***Figure 2.*** *The elements of the Activity-Based Physics Suite.*

In 1994, inspired by the accomplishments of WP indicating that some benefits could be gained from the collaborative group-learning, an interactive group-based approach called Workshop Tutorials was introduced into the University of Sydney [17], aiming at bringing modifications to the initial remedial tutorial classes which were conducted in the traditional manner and received poor response.

In 2004, the refined version of WPAG consisting of 4 books was published by John Wiley & Sons. By 2015, about 5000 college or university students at over 50 institutions have used at least one WPAG module, and more than 750 secondary schools have adopted WP materials locally with purchased licenses [10].

## 3. Briefing Workshop Physics

### *3.1. Philosophy of Workshop Physics*

When it comes to determining what matters in physics education, Workshop Physics firmly holds the belief that exposing students to more directly observable phenomena and helping them obtain scientific inquiry skills are prior to learning every piece of knowledge depicted in their textbooks. Thus, WP abandons formal lectures completely in favor of a special approach where students learn with their helpful peers and computer tools accessible to students are introduced to prompt learning efficiency. The fundamental philosophy of Workshop Physics is elaborated below [18].

#### *3.1.1. Reducing Content and Emphasizing the Process of Scientific Inquiry*

Workshop Physics agrees with the assumption that the acquisition of transferable skills in scientific inquiry appears more significant than either the descriptive knowledge about the enterprise of physics or problem solving. It eliminates several topics and emphasizes inquiry skills based on real experience for two major reasons. First, most students don't have sufficient direct experience with everyday phenomena, which will result in difficulties in comprehending corresponding abstract knowledge. Second, when confronted with the task of acquiring such an overwhelming volume of knowledge, the only viable strategy is to grasp a panoramic understanding of the whole picture and obtain methods that can be applied in multiple tasks, also known as "transferable skills". The philosophy in transferable skills follows the adage "less is more" [19].

#### *3.1.2. Emphasizing Directly Observable Phenomena*

This principle is mostly reflected in choosing learning topics. Prior to formal definitions and theoretical relationships, WP attaches more importance to operational definitions and empirical relationships. Therefore, it focuses on topics which are amenable to direct observation of phenomena, and the mathematical and reasoning skills needed for analysis in these topics are applicable to many other areas of inquiry to prepare students for further study in physics and engineering.

***3.1.3. Eliminating Formal Lectures***

While the effectiveness of lectures in improving students' abilities in scientific inquiry remains unproven, many educators believe that their peers can provide more assistance in establishing original thinking and problem solving. In other words, listening to lectures given by the instructors passively might not be so effective as anticipated. Thus, Workshop Physics eliminates formal lectures and develops a classroom-laboratory environment equipped with computer tools and science apparatus for the authentic process of scientific inquiry which allows students to spend time in direct inquiry process and in discussion with their helpful peers. This change also triggers the role transition of instructors, which is from authorities who reveal the truth to facilitators who design the creative learning environment [20] where instructors lead discussions, encourage students to participate in reflective discourses with one another and engage in Socratic dialogues with students without giving them straight answers.

***3.1.4. Using Computers as a Flexible Tool***

One of the factors that distinguishes Workshop Physics is its utilization of computers. While computer tools have had a profound effect on the nature and the scope of physics research, it should also aid students in their inquiry-based learning experience. Within the Workshop approach, students have computers at their disposal for the collection, analysis and graphical display of data, which provides efficient assistance to the inquiry process. More details on the functions of computers in Workshop Physics will be introduced in the next section.

***3.2. Organization and Resources***

***3.2.1. Course Organization***

Students meet three times a week in a customized workshop room which is about 800 square feet in size, each time for a two-hour session. Each session is outfitted with one instructor, two undergraduate teaching assistants (such as someone who has successfully completed the course) and no more than 24 students [18]. During these sessions, students are strongly encouraged to work in collaborative groups of two to four, determined by the nature of each activity, and each group shares the same set of one computer, an extensive collection of apparatus and other gadgets.

In general, students encounter each topic in a four-part learning sequence without any formal lectures [21]. First, students kick-start their learning by making predictions about the studied phenomenon based on their preconceptions. Second, students reflect on their observations and refine their conceptions. Third, they develop definitions related to the studied phenomenon and derive theoretical relationships (equations) on due topic based on their analysis with necessary mathematical approaches. Finally, students perform experiments to verify their predictions and apply their comprehension of the phenomenon to problem solving.

***3.2.2. Curriculum Resources***

***i. Textbook Materials***

The Workshop Physics curriculum is centered around a series of workbook-style textbooks called *Workshop Physics Activity Guide* (WPAG) [21]. Designed for calculus-based introductory physics courses, WPAG consists of 28 units in 4 modules (as shown in Table 1) that interweave text materials with activities, and each unit consists of learning objectives, overview and several activities. The topic selection and arrangement in WPAG is generally in sync with the standardized textbooks applied in America, but there are some modifications:

Starting with introducing WP. Due to WP's distinctive features and the essential role computer tools play in students' learning, the first unit on Introduction and Computing gives students a general introduction to how WP works and enlightens them in what ways exactly computer tools can be beneficial to their learning.

Reducing topics by approximately 25%: a) abandoning topics which require abilities that go beyond most introductory students and are difficult to acquire through direct observations, such as relativity and quantum mechanics; b) omitting topics covered in the second-year program to avoid repetition, such as waves, ac circuits, geometric and physical optics [19].

Developing new units on contemporary topics that are quite popular among students: Unit 15 on Oscillations, Determinism and Chaos [22], Unit 25 on Electronics and Unit 28 on Radioactive and Radon Monitoring.

***Table 1.*** *Workshop Physics Activity Guide modules and units.*

| Module | Unit |
|---|---|
| 1. Mechanics I (core volume) | 1) Introduction and Computing; 2) Measurement Uncertainty; 3) One-Dimensional Motion I-A Graphical Description; 4) One-Dimensional Motion II-A Mathematical Description of Constant Acceleration; 5) One-Dimensional Forces, Mass and Motion; 6) Gravity and Projectile Motion; 7) Applications of Newton's Laws |
| 2. Mechanics II | 8) One-Dimensional Collisions; 9) Two-Dimensional Collisions; 10) Work and Energy; 11) Energy Conservation; 12) Rotational Motion; 13) Rotational Momentum and Torque as Vectors; 14) Harmonic Motion; 15) Oscillations, Determinism and Chaos |
| 3. Heat Temperature and Nuclear Radiation | 16) Temperature and Heat Transfer; 17) The First Law of Thermodynamics; 18) Heat Engines; 28) Radioactivity and Radon Monitoring |
| 4. Electricity and Magnetism | 19) Electric Fields; 20) Electric Flux and Gauss' Law; 21) Electrical and Gravitational Potential; 22) Batteries, Bulbs and Current Flow; 23) Direct Current Circuits; 24) Capacitors and RC Circuits; 25) Electronics; 26) Magnetic Fields; 27) Electricity and Magnetism |

***ii. Computer Tools***

As is mentioned above, using computer tools flexibly in data collecting, analyzing and displaying can provide remarkable efficiency for students' learning. It is rather important that students gain access to these tools for the completion of activities and after-class assignments. Workshop Physics computer tools include 3 different software packages and associated computer hardware [21] described below.

*Spreadsheets*. Spreadsheet software, such as Microsoft Excel, is most commonly used for the entry of data for further analysis and graphing. In some cases, spreadsheets can be utilized for mathematical modeling. For instance, Figure 3 illustrates the sample of a few data pairs and corresponding Excel model showing a proportionality between force and acceleration.

| | | |
|---|---|---|
| Slope= | 0.75 | [kg] |
| Intercept= | 0.00 | [N] |
| | | |
| | | |
| | Force[N] | Force[N] |
| a [m/s/s] | Data | Model |
| -3.20 | -2.30 | -2.40 |
| 0.09 | 0.17 | 0.07 |
| 2.60 | 2.00 | 1.95 |
| 1.20 | 0.97 | 0.90 |
| -0.99 | -0.44 | -0.74 |

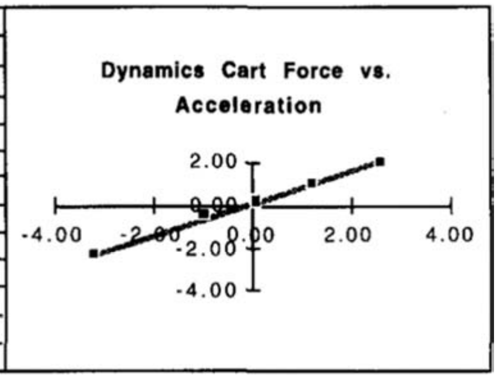


***Figure 3.*** *Sample of using Excel for modeling [23].*

*Computer-Based Laboratory Tools*. These tools are computer hardware that allows the collected data to transfer automatically to a spreadsheet for additional analysis. A computer-based laboratory system consists of a sensor plugged into a computer via an interface. Sensors implemented in WPAG include motion, force, temperature, voltage and magnetic field, etc. These tools that cooperate with computer software are available from PASCO scientific and Vernier Software, for example, the three different sensors shown in Figure 4.


***Figure 4.*** *Sensors from PASCO scientific.*

*Video-Analysis Software*. Designed to observe two-dimensional motion more explicitly, video-analysis software collaborates with a video-capture board and a video camera to allow students to analyze digitized video frames. For example, if we'd like to analyze the motion of a dancer in a video clip, we can first divide the person's body parts into different mass points (Figure 5), and track the motion of these mass points using video-analysis software.

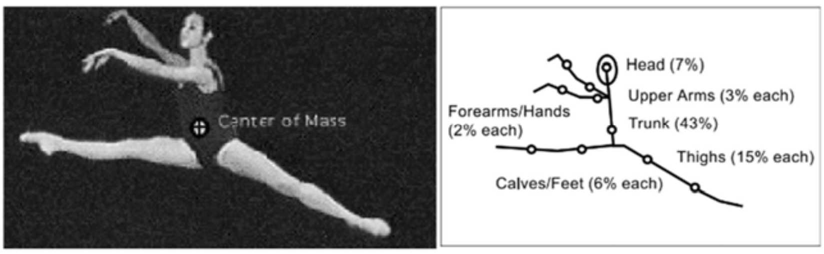


***Figure 5.*** *Idealizing the dancer as a collection of mass points [24].*

First, the software breaks the studied clip into a sequence of video frames, captures certain frames at the same interval and stores the information for later analysis. And then, students can display the frames and determine the coordinates of locations of interest on each frame selected. These data will be transferred automatically and simultaneously to a spreadsheet. Figure 6 demonstrates the process of using Capstone [13] to conduct video-analysis: use the mouse to click on the location of the ball at the same interval (white dots) to capture the data of interest, and the data will be stored and displayed as a graph (the orange one reflects x-t, the blue one reflects y-t). Apart from location, Capstone can also analyze velocity and acceleration on both axes. Other software such as SPARKvue from PASCO scientific [25] and Tracker distributed by Open

Source Physics [26] can also achieve video-analysis with different functions and advantages.

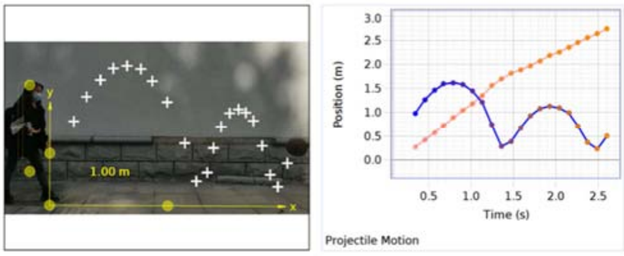


***Figure 6.*** *Using Capstone to analyze the motion of a basketball in a video.*

*Simulations*. The philosophy of Workshop Physics attaches primary significance to providing students with directly observable real-life phenomena. Therefore, computer simulations are rarely used except for the application in some activities and homework assignments. The Physics Academic Software simulations (Figure 7(a)) documented by WP researchers have been shut down permanently. However, there are still other websites that provide simulation service such as The Physics Classroom [27]. A simulation game on this website called *Electric Field Hockey* is shown in Figure 7(b). In this game, you can place several positive and negative charges on the field to drive the metal ball into the goal.

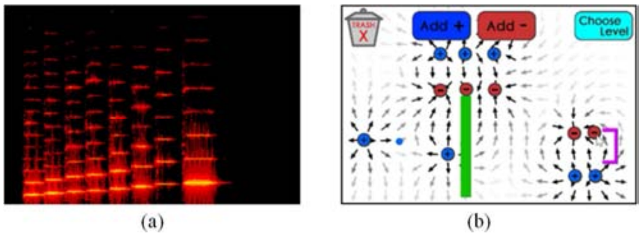


***Figure 7.*** *Simulations of a sonogram [28] and the Electric Field Hockey.*

### *iii. Apparatus*

The apparatus needed for Workshop Physics activities includes standard physics apparatus, inexpensive common items that can be acquired locally and customized Workshop Physics apparatus co-designed by the WP team and PASCO scientific. Dabbling in the fields of mechanics, thermodynamics, electricity and magnetism, optics, sound and waves, atomic and nuclear, the apparatus designed specifically for WP [21] includes Kinesthetic Cart, Equal Arm Balance, Chaotic Physical Pendulum, Mass Lifting Heat Engine and Faraday Apparatus, etc. For instance, the Wireless Smart Cart shown in Figure 8 is equipped with built-in sensors that can measure force, position, velocity, three axes of acceleration and rotational velocity.


***Figure 8.*** *Wireless Smart Cart from PASCO scientific.*

### *iv. Online Learning*

A supplemental online learning material: *Interactive Video Vignettes* (IVV). IVV is an effective technique designed to enhance out-of-class learning in introductory physics and advanced physics (under development), and it has been used in many research-based curricula including Workshop Physics [29]. Developed by the LivePhoto Physics group, IVV has accomplished the transition from passive lecture videos to active online learning vignettes by injecting interactivity and PER-based elements to short presentations. Up to now, the Interactive Video Vignettes project includes 9 vignettes, all available at its website [30]. In general, these vignettes include visualization, prediction, measurement and comparison, such as the "Newton's First Law" vignette demonstrated in Figure 9.

The "Newton's First Law" vignette contains 7 pages. Page 1 is a video where the instructor asks two students what would happen if he shoves an object and then demonstrates shoving a piece of wood on the floor. On page 2 the user learning with the vignette is asked to predict the velocity-time graph of the wood. On Page 3 the user is asked to click on the center of the wood in successive video frames to create the actual v-t graph using the video-analysis approach mentioned above (Figure 9(a)). On page 4 the user's former predictions from page 2 are echoed back to compare with the actual graph (Figure 9(b)). If they don't match, the user should know by now that his predictions are wrong. Also, on this page the instructor explains his own observations and conclusions in the video. On page 5 the instructor explains that he is going to use dry ice to simulate the frictionless situation, and on the next page the user needs to conduct video-analysis again to create the v-t graph of the dry ice (Figure 9(c)). On the last page, the instructor sums up and gives the Newton's First Law statement along with sharing his own thoughts about it. After the user has completed the whole vignette, he or she would instantly receive a certificate indicating completion.

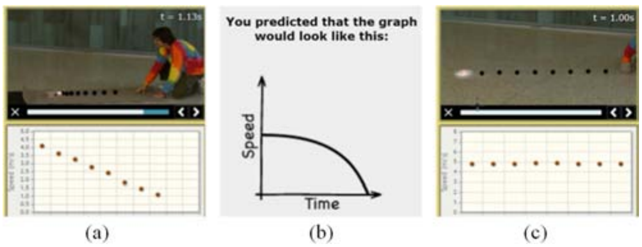


***Figure 9.*** *The "Newton's First Law" vignette.*

### *v. Assessment*

The Workshop Physics assessment tool, entitled Action Research Kit (ARK) [31], enables instructors to assess teaching effectiveness using the Action Research method [32] (instructors and students together participate in a cycle of activities including problem diagnosis, action intervention and reflective learning). ARK consists of a series of multiple-choice assessments that help examine students' improvements on conceptual learning and attitudes towards learning physics, including six assessments (five conceptual and one attitudinal) listed in Table 2.

***Table 2.*** *Action Research Kit components.*

| Assessment | Description |
|---|---|
| Mathematical Modeling Conceptual Evaluation (MMCE) [33] | Dealing with mathematical content knowledge such as representation and translation skills between equations |
| Vector Evaluation Test (VET) [33] * | Focusing on testing students' ability to conduct vector analysis including addition, subtraction and magnitude comparison |
| Force and Motion Conceptual Evaluation (FMCE) [11] | Probing students' understanding of Newtonian Mechanics including kinematics, force, energy, graphing |
| Heat and Temperature Conceptual Evaluation (HTCE) [34] | Assessing students' comprehension of thermal and statistical content knowledge |
| Electric Circuits Conceptual Evaluation (ECCE) [35] | Probing students' ability to solve problems in simple DC or AC circuits (ECCE contains short-answer questions) |
| Maryland Physics Expectations Survey (MPEX) [36] | Probing students' attitudes, epistemological beliefs and assumptions about physics |

* VET was originally published as MMCE-Ⅱ in [33].

# 4. Feedback

## *4.1. Positive Feedback*

During the practice of Workshop Physics, the positive findings about students' learning and attitudes are as follows [19].

### *4.1.1. Preference Demonstrated in Students' Attitudes*

Many students express preference for the Workshop Physics teaching method. As is mentioned in Chapter 1, students have shown great interest in the WP curriculum as they use computer tools to enhance their learning and collaborate with their group members to explore the physics content. About two-thirds of all students at Dickinson College who have taken WP in the calculus-based courses express strong preference for the WP approach over their assumption of the traditional methods.

### *4.1.2. Improved Learning and Diverse Experiences*

A greater percentage of students master concepts that are considered difficult to teach. These concepts usually involve classic misconceptions. The revealed improvements in mastering concepts derive from students' acquiring direct experience with real-life phenomena. To demonstrate the effectiveness of WP more clearly, Laws [10] compared normalized FMCE gains among three instructional settings: a) in 1995, students at Carroll College who received traditional instructions achieved gains of 0.19; b) in 1995, students at Moorhead State University who received WP during its first year of development achieved gains of 0.35; c) between 1994 and 1996, Dickinson College students who received WP at the end of the development phase realized remarkable gains of 0.65. Also, extending Hake's research [37] on students' FCI [38] performance, the study conducted by Redish [39] shows that the Hake factor $h$ of the WP classes ($0.41 \pm 0.02$), although much to improve, appears much higher than that of the traditional classes ($0.16 \pm 0.03$).

Performance of WP students in a) upper-level physics courses and b) solving traditional textbook-style problems is as good as that of students who took traditional courses. The first finding comes from the upper-level course instructors' feedback based on their impressions. The second finding is surprising because as is mentioned above, WP advocates students' direct experience, eliminates formal lectures and doesn't pay attention to textbook content and problem solving the way traditional methods do. However, students taking WP courses still manage to perform as good in textbook reading, home assignments and textbook-style problems. There are no signs indicating reduction in students' problem-solving skills in WP classes. In addition, Interactive Video Vignettes (one of WP's supplemental materials) proved to have a positive impact on students' concept learning as a study conducted at the University of Cincinnati showed supporting results [29].

Students who complete WP courses encounter a wide range of learning experiences and are considerably more comfortable working with computer tools and in laboratories. In WP classes, students experience an adequate process of scientific inquiry including predictions, observations, experiments and mathematical modeling, etc. Compared to traditional lectures, the WP method allows students to participate in learning way more actively, and after numerous practices on computers and lab apparatus, it's only reasonable that students become more proficient with them.

## *4.2. Negative Feedback*

While great news has emerged during WP's application in colleges and secondary schools, some concerning feedback has also appeared calling for further improvements [19].

### *4.2.1. Students' and Instructors' Difficulties in Adjusting*

Some students complain that WP courses are too demanding. Every coin has two sides. While WP allows students to be actively immersed in learning, it also demands students to spend more time and effort, which is why some students can't stand the inconvenience brought by WP. A small percentage of students even thoroughly dislike the approach in favor of returning to lectures, since lectures are more efficient and "easy" because they just have to sit and listen to whatever the instructor offers.

As for instructors, some express concerns on having trouble teaching in a workshop session. It is extremely challenging for instructors to accomplish the role transition from the knowledge authorities to the creator of active learning environment, since many foster their teaching instinctively by imitating their own teachers. It's difficult to break out of the traditional mold.

#### *4.2.2. Flawed Results Calling for Refinement*

While concept comprehension has generally improved, the conceptual gains of students are sometimes disappointing. For example, for the content "circuits", students at the University of Oregon who completed Workshop Physics laboratory sessions didn't perform significantly better on questions than those who only took lectures. This calls for more attention to appropriate curricular modifications.

## 5. Conclusion

Workshop Physics is a set of activity-based physics courses in a workshop setting, where students learn in collaborative groups to build concepts through the process of scientific inquiry with the aid of flexible computer tools. Through the cooperative exploring and discovering students would realize that physics is not a big pile of dull textbook content but an ongoing scientific inquiry that keeps updating itself, which means that they need to learn physics through direct experience with real phenomena and their participation of inquiry activities. During its development, WP has been applied and proven effective in both high school physics courses and college introductory calculus-based physics courses. The research results concerning WP indicate that,

a) WP has performed remarkably in helping students master challenging concepts which usually don't agree with their preconceptions;
b) Although eliminating lectures, the workshop methods still manage to maintain students' ability to read textbooks and solve textbook-style problems;
c) The majority of students enjoy learning in a workshop setting where they explore physics through fascinating activities that resemble the process of scientific inquiry as much as possible.

By reviewing Workshop Physics, instructors can gain some insights on things, such as how to help students establish and reinforce concepts in their mind and utilize modern technology more efficiently. However, some students and instructors have reflected that they have difficulties in adapting to this teaching method, and the teaching effectiveness of a small percentage of concepts has not reached the expected level. Therefore, further research on WP should be carried out, including comparing the teaching process of WP in different classroom settings, recording and analyzing the specific learning process of students from different backgrounds, so as to explore what factors determine WP's teaching effectiveness. Meanwhile, teachers engaged in WP teaching should acquire access to more timely and personalized guidance.

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