EFFECTIVE ASSESSMENTS OF INTEGRATED ANIMATIONS -- EXPLORING DYNAMIC PHYSICS INSTRUCTION FOR COLLEGE STUDENTS' LEARNING AND ATTITUDES

King-Dow Su*[1], Shih-Chuan Yeh[2]
Department of Hospitality Management[1] and Center for General Education[1,2]
De Lin Institute of Technology
NO.1, Lane 380, Ching-Yun Road, Tu-Cheng City, Taipei County
236, Taiwan, Republic of China
TEL: 886-2-22733567~137
FAX: 886-2-2273-4433
*Corresponding Author: Email: su-87168@dlit.edu.tw

ABSTRACT
The purpose of this study was to give effective assessments of three major physics animations to upgrade college students' learning achievements and attitudes. All college participants were taken from mechanical and civil engineering departments who joined this physics course during the 2011 academic year. Three prime objectives of physics instruction were: (1) to improve physics animated texts, (2) to promote positive learning achievement, and (3) to evaluate the validity of the revised physics instruction with regard to learning attitudes. Assessments of applied animations in this study contributed much to learning results of students' performance which enhanced students' physics concepts learning and attitudes indicated by different variances of gender, major, dispositions.
Keywords: animations, physics instruction, learning performance

INTRODUCTION
Effective assessments to improve students' physics instruction and learning performances, rather than merely teaching basic-level physics concepts, become the primary concern and fundamental goal for physics educators (Kiboss, 2002). Many researchers have pointed out that students rarely build a complete physics knowledge because they underestimate the complexity and relationships between prior knowledge and new knowledge without interactive animations or signaling functions (Feltovich, Coulson & Spiro, 2001). Some physics instruction of promising strategies have already been successfully explored, such as visual animations for communicated environment (Tao, 2004; Author, 2008a, 2008b, 2011, 2013), in their advanced concepts of science history (Galili & Hazan, 2001; Wang & Marsh, 2002) to help students achieve more effective physics learning. To be a constructive physics instruction of learning environment, this approach integrates visual animations into students' understanding of conceptions towards physics learning and attitudes. Several constructivists' strategies of integrated animations were included in the overall physics learning process, such as multimedia texts and hands-on inquiry experiences for students to learn fundamental physics conceptual developments. Specifically, this study would focus on three following critical learning questions:
(1) To what extent do three integrated animation units improve college students' learning conceptions for physics assessments?
(2) What effective assessments of integrated animations does this study make for upgrading students' physics learning performances?
(3) What are college students' learning attitudes to physics instruction in contrast with their prior learning and performances?

This study of three integrated animation units aims at facilitating students' effective assessments of physics conceptions and improving their physics learning attitudes. It is considered acceptable by Kiboss (2002) and Tao (2004) that physics instruction of integrated animations would be available for students of universities, colleges, and high schools as a collaborating tool in assessing learners' learning environment and performances to replace traditional physics learning (Barton, 2005).

THEORETICAL BACKGROUND
A recent research discovery reveals that college students' learning towards physics is declining not in their lack of interest, but in lack of integrated animations for instruction environment nowadays (Becerra-Labra, Gras-Martı & Torregrosa, 2012). Thus, efforts towards integrated animations are needed for positive physics learning concepts to increase students' interest and motivation. Many scholars' up-to-date strategies of physics learning are based on constructive integrated animations related to the authentic nature of physics instruction. There are several potential advantages for this study to get effective assessments of rich integrated animations which closely parallel with new technologies of physics instruction. This study also offers physics teaching activities including three integrated animation units in the learning environment suitable for a constructive assessment of

students' learning performances.

CONSTRUCTIVIST APPROACHES IN PHYSICS INSTRUCTION

It is a new tendency that physics learning requires to build a persuasive learning environment for college students' integrated animations with constructivist instruction. Constructivism would be an interactive epistemology which defined students' constant competence and demonstrates their understanding of real knowledge. Hodson (1996) classified four important constructivist aspects based on the literature survey: to identify students' ideas and views; to create opportunities for students to explore their conceptions, to provide stimuli for students to develop new ideas; and to support their attempts to rethink and reconstruct their own ideas and views. Tenenbaum, Naidu, Jegede, and Austin (2001) presented seven key constructivist factors for students' physics learning environment: (1) dealing with arguments, discussions, debates; (2) meeting conceptual conflicts and dilemmas; (3) sharing ideas with others; (4) measuring targeted materials toward solutions; (5) organizing reflections and conceptual investigations; (6) fitting students' needs; and (7) making meaningful, real-life examples. All seven factors emphasized students' dynamic fulfillment that real knowledge was actively constructed in learners' mind step-by-step. For last few decades, the importance of the constructivist perspective has been stressed by educators for improving students' learning performances. Ausubel (1968) indicated that the fundamental principle of constructivist instruction was to assess what students knew and then to design activities and assessments of their performances accordingly. Constructivist principles had been interpreted in a variety of scientific ways ranging from information processing, interactive and social constructivist to physics instruction (Yore, 2001). Both constructivist principles and students' conceptual changes were influential in physics instruction, and they were inseparable from any physics instruction. This study explored the constructivist-based physics instruction which had been in accordance with the conceptual change models (Posner, Strike, Hewson, and Gertzog, 1982) to help students modify their misconceptions and develop better learning performances.

TECHNOLOGY ENRICHMENT FOR THE ANIMATED LEARNING ENVIRONMENT

College students who face rapid changes in the modern world will be in great need of technological instruction with effective animated learning environment. More than one decade, Gilbert (1999) proposed a new strategy of integrated animations to enhance students' science learning environment. He said that much scientific learning was too abstract to interpret, and those complicated ideas would prevent students from constructing mental models and their subsequent learning performances. Several means of physics instruction had been dealt with, such as models, analogies, equations, graphs, diagrams, pictures, mathematical operations, and visual and action images (Lemke, 1998). All these could be functional with integrated animations for different effects of a single representation compared to multiple representations (Yore & Treagust, 2006). Several multiple representations (Spiro & Jehng, 1990; Paivio, 1971 &1991) could be in collation with Ainsworths' learning frameworks of the ubiquitous DeFT (design, functions, and tasks 1999, 2006) for students' animated learning environment. A common justification for using multiple representations responded to the fact that they captured students' interest and, in doing so, played an important role in promoting animated environment for students' learning performances.

LEARNING THEORY AND MULTIMEDIA ENVIRONMENT

Verbal and visual inputs would construct multi-functions of dual-coding theory (Paivio, 1971 & 1991) in students' integrated animations of physics learning environment (Butler & Mautz, 1996). Both verbal and visual systems could be linked and inter-communicated for the cueing combination of one system to the other, which in turn facilitated students' integrated animations of physics instruction. Theoretical principles from this multimedia-orientated environment would offer fundamental presentations as texts and animated sequences which all interacted together to enhance students' learning performances (Mayer, 1997; Moreno & Mayer, 1999). The contiguity principles for computer-based instruction gave students effective impact when words and pictures were presented contiguously in time or space (Mayer & Anderson, 1991; Mayer & Sims, 1994). Learners might construct three basic principles for integrated animations of both words and pictures in their learning environment:

- Principle 1: To improve understanding and performance, learners should get more involved in building multimedia connections between verbal information and learners' visual representations.
- Principle 2: To evaluate physics instruction effectively, learners should construct integrated animations between pictorial information and learners' visual representations of that information.
- Principle 3: To upgrade learning attitudes, learners should address referential environment between corresponding elements in verbal and visual representations.

To sum up, the multimedia environment of integrated animations included digital combinations of words, graphs, animations, and sound in physics instruction. All functions and demonstrations designed to attract students' visions, could stimulate their motivations to learn, and create effective integrated animations in their physics learning environment (Rieber, 1996; Mayer, 1999; Sperling, Seyedmonir, Aleksic and Meadows, 2003).

INSTRUCTIVE APPLICATIONS OF INTEGRATED ANIMATIONS

Instructive applications for three unit integrated animations should focus on students' effective physics learning in terms of constructing knowledge and promoting related physics competence. The purpose of this study was to construct students' instructive applications of physics knowledge cognition from three integrated animation units. The instructive applications of integrated animations made students' physics learning and research methods towards multi-faceted, flexible, and more effective. Some advantages of physic applications in integrated animations were: (a) to increase students' interest and ability to retain the subject materials; (b) to illustrate physics conceptions in a number of ways not available to lecturers' writing on the chalkboard; and (c) to present multimedia demonstrations for students outside the classroom via computer or video (Whitnell et al., 1994). Critical questions as to why integrated animations of physics instruction could increase students' conceptual understanding had been addressed by many researchers (Ardac & Akaygun, 2004; Kiboss, 2002; Schoenfeld-Tacher, Jones & Persichitte, 2001). Ainsworth (1999) proposed a functional taxonomy of multiple representations, for the promoted understanding of deeper learning conceptions that might include abstract generalization and related teaching between representations. Kiboss (2002) implied that module applications of integrated animations for physics instruction would upgrade students' understanding of concepts and skills. Tao (2004) employed computer-based designs of peer collaborative learning instructions to help students develop image formations via a lens, and to further improve these image formations. Barton (2005) explored that innovative changes to support teachers' useful integrated animations of physics instruction made successful developments in scientific education. However, not all applications of integrated animations were necessarily appropriate or an effective strategy for improving students' learning performances (Lin & Dwyer, 2004). Sperling et al. (2003) argued that regardless of inconsistent findings about multimedia, authentic science materials were needed to facilitate appropriate and functional physics instruction. Mayer, Hegarty, Mayer and Campbell (2005) concluded different phenomena in several physics experiments. They used the same descriptions and graphics for both paper-based and computer-based versions of lightning formations in the following experimental process -- how a toilet tank worked, how ocean waves formed, and how the car braking system operated. They found that the static illustrations reduced extraneous and promoted germane processing, when compared with narrated animations. Recent advancements in physics instruction of integrated animations had allowed educators to incorporate texts as well as visual and sound resources into students' learning environment. Some researchers indicated that the incorporation of integrated animations into physics courses could upgrade students' understanding and different levels of achievements (Barton, 2005; Tao, 2004; Kiboss, 2002).

This study responded to two critical questions. First of all, what kinds of animations and animated environment would be pertinent for integrated instruction in college physics learning? Secondly, how could we modify students' feedback in physics learning achievements and attitudes for applications of three integrated animation units?

METHODOLOGY

The overall research methodology was comprised of three effective assessments, including pretests, posttests and questionnaire for non-major college students in the required physics courses. Since few contemporary physics education programs had been effectively implemented in Taiwanese colleges, the present study focused on undergraduates' learning performances to upgrade their competence via integrated animations of physics instruction. All pretests, posttests and follow-up questionnaire had assessed students' performances in the multimedia physics instruction. It was assumed that integrated animations of physics instruction was crucial to students' understanding since many college students were often too shy to ask questions either during or after classes. It was believed that physics instruction of three integrated animation units would stimulate more interactions between students-students and instructors-students suitable for students' learning competence and individual characteristics.

PARTICIPANTS

Assessments of statistical samples for group surveys were taken from college students in the present researcher's physics classes. All participants (N = 193) were recruited as tentative samples from both civil engineering and mechanical engineering departments by a stratified procedure to eliminate voids in the sampling frames. All students' characteristics -- such as gender (male, 92.2%; female, 7.8%), majors (civil engineering, 35.8%; mechanical engineering, 64.2%), dispositions towards computer learning (positive, 28.5%; neutral, 57.5%;

negative, 14.0%), and attendance at computer orientation classes (yes, 74.1%; no, 25.9%), were used to define the sampling frames and potential blocking variables for the data analyses.

TOOLS

There were four major assessment tools in the data collection and analyses stages: namely, (a) pretests, (b) physics instruction of three integrated animation units, (c) posttests, and (d) a follow-up questionnaire. Several pretests and posttests appropriate to three integrated physics units were developed to assess students' learning achievements and learning attitudes. All tests with computer-based analyses were focused on three categories: knowledge, comprehension, and applications (Bloom et al., 1956). A ratio sampling frame from the "kinetic energy and work" unit was exemplified by -- knowledge (30%), comprehension (40%) and applications (30%) as the following 3 items from 10 item models:

(1) Knowledge Orientation (only 1 item from 3 item models)-- If one can lift up a ball with a mass of 0.4 kg straight up at a constant speed through a displacement of 5 m, the total work needed to move the ball would be _____.
Answer: (A) 0 J (B) 19.6 J (C) 5 J (D) -19.6J (E) 72 J.

(2) Comprehension Orientation (only 1 item from 4 item models) -- A brick with a mass of 6.00 kg initially at rest is pulled to the right by a constant horizontal force with the magnitude F = 12.0 N. What will the speed of the brick be after it has been moved 3.0 m? _____
Answer: (A) 0 m /s (B) 2.4 m /s (C) 3.5 m /s (D) 4.2 m /s (E) 5.5 m /s.

(3) Application Orientation (only 1 item from 3 item models) -- What is the speed of the brick after it has been
moved 3.0 m if the surface has a 0.15 coefficient of kinetic friction with which it is in contact?
Answer: (A) 0 m /s (B) 1.8 m /s (C) 3.5 m /s (D) 4.2 m /s (E) 5.5 m /s.

Both pretests and posttests for three physics units were administered by local physics professors of the Entrance Examination Center in Taiwan to assess different test validities. The reliability of students' achievement tests was analyzed in Cronbach's alpha coefficients for the pretests and posttests, which were 0.78 and 0.79 respectively. Kline (2005) posited that the α value up 0.70 was considered acceptable. The same test validities were combined together with pretests and posttests to detect students' differential physics learning performances.

Effective assessments of students' learning attitudes in the questionnaire were devised by the author (2008a, 2008b, 2011). The Likert 5-point scale was used to evaluate students' physics learning attitudes. Each test item had five responsive categories, ranged from item 1 (strongly disagree) to item 5 (strongly agree). The questionnaire included six aspects as the following descriptions:

(S_1) Learning Attitude towards Integrated Physics Units
Students' attitudes towards their competence in integrated physics courses depended on what new information they learned from multimedia aids, and what conceptions they could construct from integrated animations of their learning programs.

(S_2) Learning Attitude towards Physics Instructors
Most students believed that instructors were always satisfied with and encouraged by better grades and learning achievements. If they got higher grades, they could be more actively involved in integrated animations of physics learning programs. Thus, physics instructors' opinion influenced students' learning motivation.

(S_3) Learning Attitude towards Integrated Physics Learning Environment
Students' assessments of integrated physics learning units depended on a well-equipped multimedia environment.

(S_4) Learning Attitude towards Students' Interactions
A positive learning attitude towards collaboration and integrated animations of physics units was required in the learning process. Interactions between students helped them to solve their problems, develop good learning habits, and provide meaningful discussions of integrated physics learning.

(S_5) Learning Attitude towards Self-evaluations
Most students believed they could perform well with the help of the integrated learning environment; after previews and reviews, students could make self-assessments, finish required assignments, and improve their integrated physics learning grades.

(S_6) Learning Attitude towards Integrated Physics Learning Results
The better learning attitudes students had the more positive the integrated learning results they could demonstrate. Most students felt more satisfied with their integrated learning as their competence and achievement increased. Integrated physics learning helped improve students' problem-solving abilities,

increase their knowledge of basic physics conceptions, and broaden their interest in pursuing more new knowledge.

Effective attitude assessments of the questionnaire were evaluated according to the content, constructive validity and internal consistency reliability. Three specialists were asked to set up the validities of the questionnaire content. Pilot versions of the questionnaire were examined using principle component factor analyses to verify the structure and alignment given the designed constraints. Factor analyses revealed six factors with Eigenvalues over 1.0 and a cumulative total variance of 74%. Orthogonal rotation was conducted by the Varimax option support and six subscales described were identified. The results of both expert analyses and factor analyses confirmed all validities. Reliability was explored in terms of Cronbach's α coefficient to determine the internal consistency of total subscales. The analyses of six subscales separately yielded different coefficients ranging from 0.92 to 0.96 (S_1=0.96, S_2=0.92, S_3=0.93, S_4=0.94, S_5=0.94, and S_6=0.96). Compared to the previous report of average reliabilities, this questionnaire had a higher reliability than statistical data by most other researchers (Katerina & Tzougraki, 2004).

TREATMENTS

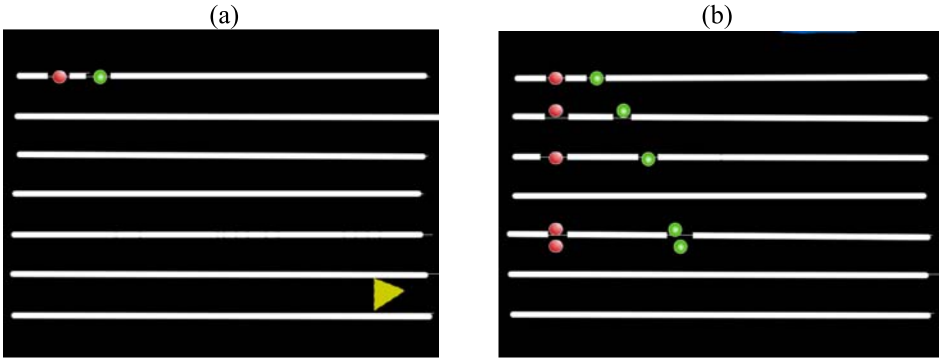
Three integrated physics units were conducted for effective learning assessments. These integrated physics units normally involved 3 hours of lecture demonstrations and 3 hours of laboratory hand-work each week. The lecture demonstrations programs were redesigned to be enriched with supplemental programs. The supplementary materials (such as animations and slides), lectures, and demonstrations all combined within an integrated learning environment in well-equipped facilities. These component programs were developed by the author drawn from the literature (Ainsworth, 1999; Yore and Treagust, 2006) and constructivist perspectives. Six integrated features of physics courses were covered in the instructional designs and computer animations as the following way:

1. Three integrated animation units were employed for specific visualizations of physics instruction.
2. The recognition of integrated environment determined the important priority of meaningful physics instruction.
3. Concrete creative images and mental assemblages facilitated students' memory and understanding.
4. Integrated interactions of physics learning between teachers and students were reinforced and encouraged in this study.
5. Guided learning with the integrated environment as a catalyst would achieve greater physics instruction goals and overcome students' learning obstacles.
6. Integrated physics presentations and demonstrations proposed opportunities and activities for students' real-life learning.

Three integrated animation units were produced in Flash MX (Macromedia Inc.), static visuals were made with Mathematica 4.2 (Wolfram Research, Inc.), and classroom demonstrations were presented by PowerPoint or e-plus software. The conceptions, ideas and dynamic processes were operated in Adobe Photoshop 7.01. Three integrated animation units were separately indicated from [Figure 1] to [Figure 3].

[Figure 1] showed visual animations of kinematics involved in the whole physics process. When one ball was released from rest; another ball fell horizontally to the right at the same instant. Their vertical motions were identical. Students were required to understand the physics motion process so multimedia animations recorded this whole dynamic process. From these animations, students needed a full physics understanding of vertical and horizontal motions, which were identical to each other in their importance. The whole animated presentations could help students to understand effectively and to solve conceptual related problems of kinematics.

(a) (b)



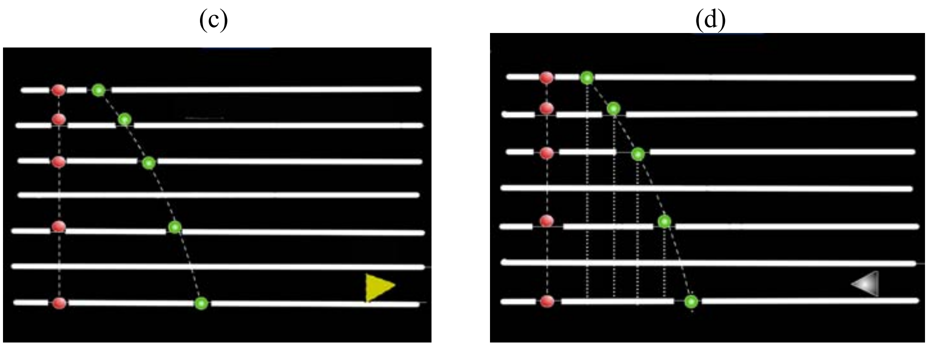


Figure 1: Selected illustrations and corresponding conceptions from the integrated physics courses with kinematics animations conducted by Photoshop 7.01, as shown in the sequence from slides (a) to (d)

[Figure 2] indicated the passing movements of a ray from one medium V_1 into another medium V_2. The angle of refraction was different from that of incidence. This case would always be the same during reflections when the ray entered a medium at a speed less than the speed of light. Snell's law was the basic requirement of refraction derived from light theory. The sequence presentations of integrated animations, as seen from pictures (a) to (d) in [Figure 2] step by step, provided an effective domination for the conception of the incident wave and the refracted wave. Most students who came from a vocational school background did not have much advanced concepts of abstract physics and dynamic processes; therefore, these animated documents helped students build a sound, basic recognition of refractions and avoid the difficulty and confusion of physics geometric optics as encountered in their daily lives.

The principal animations for the conservation of mechanical energy could be seen in [Figure 3] -- as a

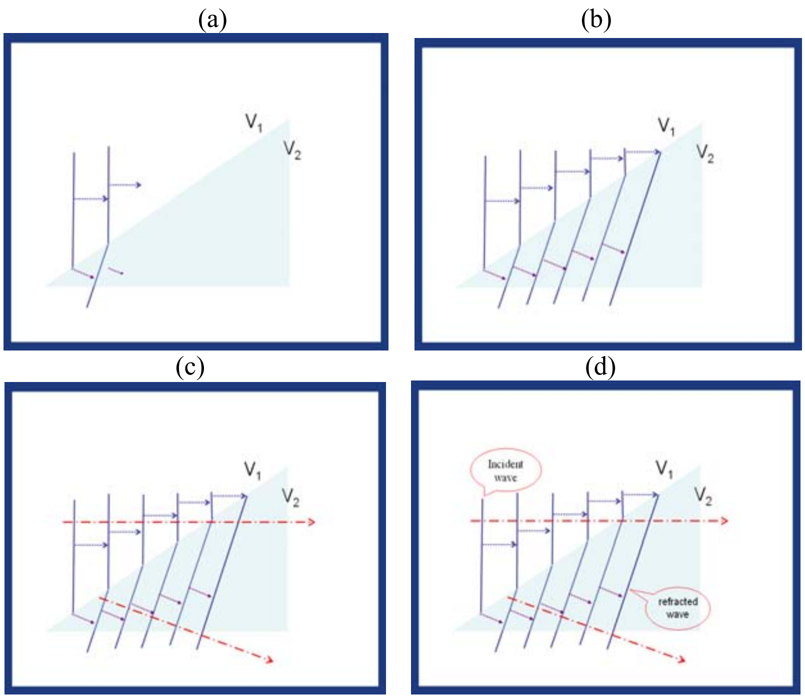


Figure 2: Selected illustrations and conceptions from the integrated physics courses with corresponding animation arrangements and movements for the ray passing from medium V_1 into medium V_2, conducted by Photoshop 7.01, as shown in different sequences from slides (a) to (d).

pendulum swung in a motion system, and the energy was transferred back and forth between kinetic energy K and gravitational potential energy U, as shown from pictures (a) to (f) in [Figure 3], with the sum K+U being constant, as shown in [Figure 3]. The slides indicated a vivid physics illustration of the conservation energy. Any energy that did not serve the intended purpose must be subtracted from the total sum in order to obtain the amount of useful energy. This physics application was very straightforward. This experiment of integrated physic mechanical energy saved students from the misunderstanding of interpreting the abstract conceptions of mechanical energy. These animations were available for solving conceptual problems related to the principle of the conservation energy.

DATA MANAGEMENT AND ANALYSES

Pretests, posttests and responsive questionnaire were collected and assigned in identified groups and codes. Six blocking variables were used to form four comparative groups: gender (male, female), major departments (civil

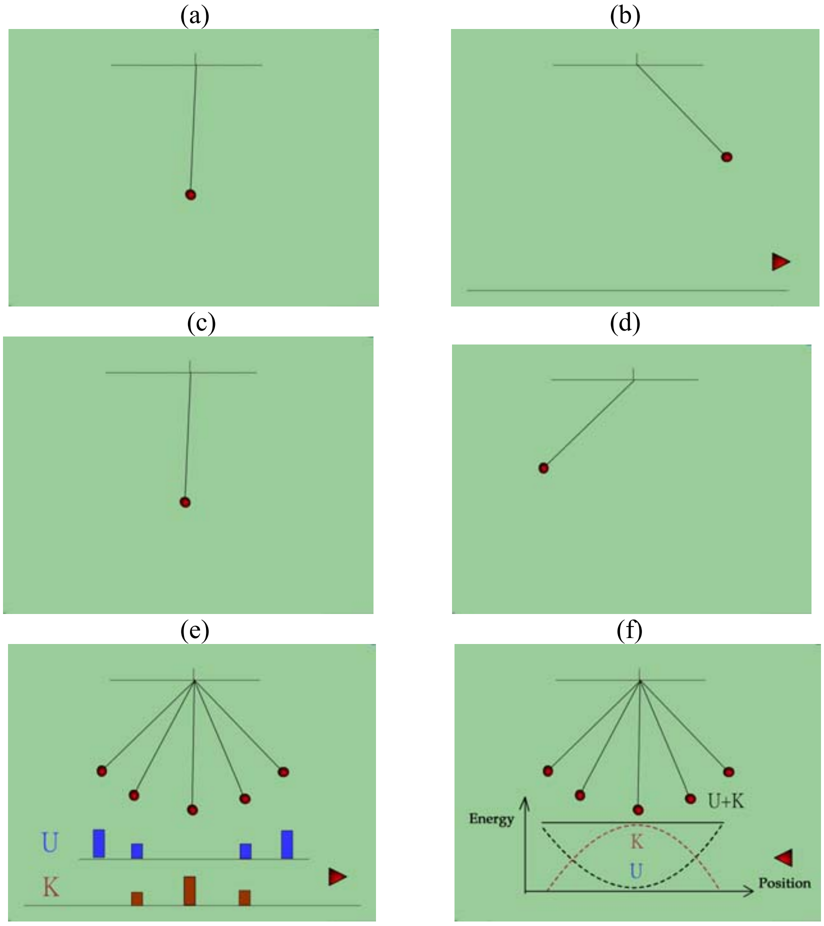


Figure 3: Selected illustrations and concepts from the integrated physics courses with corresponding animations for the conservation principle of mechanical energy, conducted by Photoshop 7.01, as shown in sequences from slides (a) to (f)

engineering, mechanical engineering), dispositions toward integrated physics courses (negative, neutral, positive), and attendance at physics learning (yes, no). All quantitative data were employed for statistical analyses functioned by the SPSS of Windows 10.0 software. Descriptive statistics (sample sizes, means, and standard deviations) were calculated for two comparative groups, and the significant levels for one-way analyses of covariance (ANCOVA) were set at 0.05 to examine main effects. In cases where *p*-values were less than or equal to 0.05, Scheffe's post hoc comparisons were conducted on different significant effects. Regarding students' changes in achievements and attitudes, the differential effects were explored and identified by the categories of blocking variables for the integrated physics learning.

RESULTS

The major perspective of this study focused on three physics units with integrated animations available for Taiwan technical college students. Blocking variables for the data analyses corresponded to differentiated requirements of students' learning performances in implemented conditions and learning attitudes. The design principles and study developments had already been described in the above sections. Next this study examined students' learning performances before and after attending instruction tests in these integrated physics programs. Students' learning performances were documented and analyzed by means of pretests and posttests; the means and standard deviations were calculated by descriptive statistics, and improvements brought about by three physics units (see Table 1). Average performances throughout pretests and posttests for three physics units indicated students' different scores from 10 to 20 points. These scores corresponded to percentage improvements of 35.8% in the kinetic energy and work unit, 30.3% in the optics unit, and 16.5% in the kinematics unit. The total improvement for three physics units was 26.5%, and effect size found by one-way ANCOVA testing was $f = 0.279$, the above medium effect. The effect size was used as the factor or index to differentiate variations in students' learning behaviors. Cohen (1994) pointed out that the effect size had more research efficiencies than the *p*-value. The testing results of statistical significance revealed occurrence rates. The effect size put important emphasis on the measurements of the relative magnitude for the experimental results. Although both testing results of statistical significance and effect size showed the size of the experimental effect, effect size became especially influential when comparing the magnitude of experimental treatments to other experimental effects. Cohen noticed that, "the effect size of one-way ANCOVA was represented by $f = [\eta^2 / (1-\eta^2)]^{½}$, in which η^2 indicated Eta square to show different efficient, $f = 0.1$ as the smaller effect size, $f = 0.25$ as the medium effect size, and $f = 0.4$ as the higher effect size" (Cohen, 1988). Inspective results of students' attitude survey (with four subscales) indicated reasonable attitudes towards physics learning.

Table 1: Mean scores（M）, standard deviations（SD） and percentage improvement of students' integrated physics learning.

Test	Course Content	Number	Pretest		Posttest		Percent Improvement*
			M	SD	M	SD	
1	Kinetic energy and Work	65	45.77	10.91	62.15	13.75	35.8%
2	Optics	59	46.44	12.25	60.53	12.93	30.3%
3	Kinematics	69	55.43	16.17	64.57	13.14	16.5%
Average		--	49.43	14.07	62.52	13.32	

Note: *Totally effect sizes, $f = 0.279$

Detailed statistics of variances and covariances were analyzed to examine the differential effects of integrated instructions on civil and mechanical engineering students' physics learning achievements and attitudes. The main effects of the integrated physics courses for students' achievements (for the given variables) were tested by a series of ANCOVAs in which the pretest results were utilized as the covariances. All ANCOVA results revealed that when students' performances of posttests were adjusted by performances of pretests, different significant main effects appeared. The statistical parameters, *F*-ratios, *p*-values and effect sizes (*f*) for each of 12 ANCOVAs for gender, major, dispositions towards computers and orientation attendance (for each of three physics courses and four blocking variables) were summarized in [Table 2]. All ANCOVA results revealed significant main effects between mechanical and civil engineering students in kinematics ($F = 4.209$, $p = 0.044$, $f = 0.259$) and kinetic energy and work content achievements ($F = 22.100$, $p = 0.001$, $f = 0.593$), with above medium or higher effects, but not in the optical units ($F = 1.328$, $p = 0.254$, $f = 0.153$). Non-significant ($p > 0.05$) main effects were found for gender, disposition towards multimedia, and attendance at computer orientation classes for all three integrated physics units. All effect sizes were below the medium effect ($f < 0.25$).

Table 2: Summary of *F*-ratios, *p*-values and effect sizes (*f*) for each of the ANCOVAs

Blocking Variables	Analyses of Variance	Physics Content Achievement		
		Kinetic Energy and Work	Optics	Kinematics
Gender (male, female)	*F*-ratio	.027	.010	.084
	p-value	.870	.920	.772
	f	.123	.132	.123
Major (civil, mechanical engineering)	*F*-ratio	22.10	13.28	4.209
	p-value	.001*	.254	.044*
	f	.593	.153	.259
Disposition toward multimedia (positive, neutral, negative)	*F*-ratio	.515	1.575	.649
	p-value	.600	.216	.526
	f	.128	.237	.146
Attendance (yes, no)	*F*-ratio	.044	.075	1.663
	p-value	.835	.786	.202
	f	.123	.128	.163

Note: * $p < 0.05$

The questionnaire results showed students' differential physics learning attitudes. The four survey subscales indicated positive attitudes toward integrated physics units, with the statistical mean responding > 4.00 for all learning attitudes. The descriptive statistical mean and standard deviations for students' learning attitudes (for six subscales and the total survey) were indicated in [Table 3]. Differential effects of the integrated physics units were explored for taking a variety of students' characteristics into consideration. The main effects of the integrated physics units (with six attitude subscales for the six blocking variables) were tested by a series of ANCOVAs. The final testing was done on the combined samples since each student had to complete the same attitude survey. [Table 4] provided a brief summary of the *F*-ratios, *p*-values and effect sizes (*f*) in 24 ANCOVAs for gender, major, disposition towards integrated physics courses, and students' attendance.

Table 3: Descriptive statistics for the mean scores (M) and standard deviations (SD) for students' integrated physics learning attitudes for six subscales and the total survey.

Scores	Attitude			Measurement			
	S_1	S_2	S_3	S_4	S_5	S_6	Total
M	4.22	4.15	4.03	4.08	4.03	4.14	4.11
SD	0.17	0.20	0.07	0.17	0.16	0.24	0.33

The statistic ANCOVAs revealed significant main effects of gender on students' learning attitudes, favoring males over females (S_4) ($F = 3.885$, $p = 0.050$, $f = 0.143$), and self-evaluation (S_5) ($F = 4.621$, $p = 0.033$, $f = 0.157$). The effect sizes ranged between 0.1 and 0.2, indicating small and medium effects. Students demonstrated a non-significant gender effect of attitudes towards integrated physics units (S_1), attitude towards the physics instructors (S_2), attitude towards integrated physics learning environment (S_3), and attitude towards integrated physics learning results (S_6). These effect sizes were all below 0.14, only a small effect. Non-significant ($p > 0.05$) main effects were found for student's major (either mechanical or civil engineering) on all six attitude subscales.

The main effects of ANOVAs significance testing showed that students who attended the learning activities had a favorable attitude towards integrated physics units (S_1) ($F = 8.694$, $p = 0.004$, $f = 0.215$), attitude towards the physics instructors (S_2) ($F = 7.509$, $p = 0.007$, $f = 0.199$), attitude towards students' interactions (S_4) ($F = 4.590$, $p = 0.033$, $f = 0.153$), and attitude towards integrated physics learning results (S_6) ($F = 4.059$, $p = 0.045$, $f = 0.146$); all effect sizes ranged from small up to medium. Non-significant ($p>0.05$) main effects were found for two other subscales: learning attitude towards integrated physics learning environment (S_3) and self-evaluation (S_5).

Significant positive main effects were found for dispositions towards integrated physics units for all attitude subscales: attitude towards integrated physics units (S_1) ($F = 18.943$, $p = 0.001$, $f = 0.446$), learning attitude towards the physics instructors (S_2) ($F = 21.131$, $p = 0.001$, $f = 0.472$), attitude towards the integrated physics learning environment (S_3) ($F = 10.439$, $p = 0.001$, $f = 0.331$), attitude towards students' interactions (S_4) ($F = 12.067$, $p = 0.001$, $f = 0.357$), attitude towards self-evaluation (S_5) ($F = 14.741$, $p = 0.001$, $f = 0.393$), and attitude towards integrated physics learning results (S_6) ($F = 20.378$, $p = 0.001$, $f = 0.464$). The effect sizes ranged between 0.331 and 0.472, indicating medium and higher effects. Scheffe's post hoc comparison results revealed that S_1, S_2, and S_5 students' attitudes reporting 'positive' were superior to those reporting 'neutral' and 'negative', and attitudes reporting 'neutral' were superior to those reporting 'negative.' The results of Scheffe's post hoc comparisons revealed the same integrated physics learning results that S_3, S_4, and S_6 students' attitudes reporting 'positive' were superior to those reporting 'negative', and attitudes reporting 'neutral' were superior to those reporting 'negative.'

Table 4: Summary of *F*-ratios, *p*-values and effect sizes (*f*) for each of the ANCOVAs

Blocking Variable	Analyses of Variance	Attitude Measurement					
		S_1	S_2	S_3	S_4	S_5	S_6
Gender (male, female)	*F*-ratio	2.718	1.642	3.771	3.885	4.621	3.133
	p-value	0.101	0.202	0.054	0.050*	0.033*	0.078
	f	0.119	0.095	0.139	0.143	0.157	0.128
Major (civil, mechanical engineering)	*F*-ratio	1.004	0.001	0.524	0.727	1.898	2.859
	p-value	0.318	0.977	0.470	0.395	0.170	0.092
	f	0.071	0.071	0.055	0.063	0.101	0.123
Disposition toward multimedia (positive, neutral, negative)	*F*-ratio	18.943	21.131	10.439	12.067	14.741	20.378
	p-value	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*
	f	0.446	0.472	0.331	0.357	0.393	0.464
Attendance (yes, no)	*F*-ratio	8.694	7.509	1.652	4.590	3.286	4.059
	p-value	0.004*	0.007*	0.200	0.033*	0.071	0.045*
	f	0.215	0.199	0.095	0.153	0.132	0.146

Note: * $p < 0.05$

CONCLUSIONS

It would be a promising strategic teaching for this research to integrate both animations and physics instruction into upgrading students' learning performances. The validity of this study exemplified many characteristics of integrated animations and animated environment in previous research results (Author, 2008a, 2008b, 2011, 2013; Kiboss, 2002; Tao, 2004), which contributed much to students' scientific learning competence and proficiency. As an effective integrated study, all the statistical physics learning results discussed above were consistent with most recent advanced researches (Tenenbaum, et al., 2001; Kiboss, 2002; Tao, 2004). In order to present students' better targeted programs of physics understanding and promote a more positive attitude towards physics learning, all ANCOVAs findings of students' characteristics such as gender, dispositions toward integrated physic courses, and attendance at the integrated physics learning programs had a major significant ($p < 0.05$) influence on their attitudes, with higher effect sizes than other variants considered.

Three major animation principles concerning the properties of physics learning environment such as kinematics, the movement of a ray and the conservation of mechanical energy (indicated in Figure 1, Figure 2 and Figure 3) gave students to organize reflections on the effective learning of physics conceptions. Based on the analyses of statistical responses, students were able to identify fundamental concepts between animations environment and physics learning. The integrated texts and physics learning environment helped to develop more unifying principles and meaningful higher-level skills which would enhance students' physics understanding and facilitate their learning performances. The integrated animations environment of physics learning provided a powerful means for fostering physic principles because it could illustrate multi-level physics conceptions (Galili, 1996; Kiboss, 2002). All results of three major animations supported and facilitated students' physics conceptions learning and attitudes.

The integrated statistic results of three animation units in this study were well-organized and helpful for most college students' effective physics learning. It would significantly make a positive contribution to students' physics learning attitudes. The results gave more reliable implications to previous researches (Barton, 2005; Tao, 2004; Kiboss, 2002) in relation to integrated physics materials and demonstrated applications which could encourage students to construct a better physics conceptual understanding. As stated by Ainsworth (2006, p. 183), the DeFT (Design, Functions, Tasks) learning framework needed to integrate the cognitive representations and constructivist theories of education into multiple research programs. He proposed that the effectiveness of multiple representations could best be understood by considering three fundamental learning aspects: the design parameters that were unique to learning environment; the functions that supported integrated physics learning; and the cognitive tasks that must be undertaken by learners' interactions with multiple representations. All three major animations increased students' learning perspective and cultivated physics conceptions. Through the availability of three principal animation texts, students were capable of more effective performances for developing physics conceptions and learning environment.

ACKNOWLEDGEMENTS

The author would like to thank the journal editors and the anonymous reviewers of this paper for their kind assistances and helpful suggestions. A short but sincere thank must also be given to the patronage of the National Science Council, R.O.C. in Taiwan (under Grant No. NSC 101-2511-S-237-001 & NSC 102-2511-S-237-001). Without their help, this study could not have been completed in present form. Finally, thanks must also be given to all the instructors and students who participated in this research study.

REFERENCES

Ainsworth, S.E. (1999). The functions of multiple representations. *Computers and Education, 33*, 131-152.

Ainsworth, S.E. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16(*3), 183-198.

Ardac, D. & Akaygun, S. (2004). Effectiveness of multimedia-based instruction that emphasizes molecular representations on students' understanding of chemical change. *Journal of Research in Science Teaching, 41*, 317-337.

Ausubel, D.P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart & Winston.

Author (2008a). *Computers & Education*.

Author (2008b). ***I**nternational Journal of Science and Mathematics Education.*

Author (2011). *International Journal of Environmental and Science Education.*

Author (2013). *Journal of Computer Engineering Informatics.*

Barton, R. (2005). Supporting teachers in making innovative changes in the use of computer-aided practical work to support concept development in physics education. *International Journal of Science Education, 27,* 345-365.
Becerra-Labra, C., Gras-Martı, A. & Torregrosa, J. M. (2012). Effects of a Problem-based Structure of Physics Contents on Conceptual Learning and the Ability to Solve Problems. International Journal of Science Education, 34(8), 1235-1253.
Bloom, B. S. Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: Handbook 1, The cognitive domain.* New York: David Mckay Co.
Butler, J.B. & Mautz, R.D., Jr. (1996). Multimedia presentations and learning: A laboratory experiment. *Issues in Accounting Education, 11*(2), 259-280.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd Ed). Hillsdale, NJ: Lawrence Erlbaum Associates Inc.
Cohen, J. (1994). The earth is round ($p < .05$). *American Psychologist, 49*(12), 997-1003.
Feltovich, P. J., Coulson, R. L. & Spiro, R. J. (2001). Learners' understanding of important and difficult concepts: A challenge to smart machines in education. In P. J. Feltovich & K. Forbus (Eds.), Smart machines in education (pp. 349–376). Cambridge, MA: MIT Press.
Galili, I. (1996). Students' conceptual change in geometrical optics. *International Journal of Science Education, 18(7)*, 847-869.
Galili, I. & Hazan, A. (2001). Experts' views on using history and philosophy of science in the practice of physics instruction. *Science & Education, 10,* 345-367.
Gilbert, J. (1999). On the explanation of change in science and cognition. *Science and Education, 8*, 543-577.
Hodson, D. (1996). Laboratory work as scientific method: Three decades of confusion and distortion, *Journal of Curriculum Studies*, *28*, 115-135.
Katerina, S. & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education, 88,* 535-547.
Kiboss, J.K. (2002). Impact of a computer-based physics instruction program on pupils' understanding of measurement concepts and methods associated with school science. *Journal of Science Education and Technology*, *11*, 193-198.
Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd Ed.). New: York: Guilford Pres.
Lemke, J.L. (1998). Multimedia meaning: Visual and verbal semiotics in scientific text. In J.R. Martin & R. Veel (Eds.), *Reading science* (pp. 87-113). London: Routledge.
Lin, C. L. & Dwyer, F. (2004). Effect of varied animated enhancement strategies in facilitating achievement of different education objectives. International Journal of Instructional Media, 31, 185–194.
Mayer, R.E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist, 32*, 1-19.
Mayer, R.E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research*, *31*, 611-623.
Mayer, R.E. & Anderson, R.B. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, *83*, 484-490.
Mayer, R.E., Hegarty, M., Mayer, S. & Campbell, J. (2005). When static media promote active learning: Annotated illustrations versus narrated animations in multimedia illustration. *Journal of Experimental Psychology/Applied*, *11*, 256-265.
Mayer, R.E. & Sims, V.K. (1994). For whom is a picture worth a thousand words: Extensions of a dual-coding theory of multimedia learning? *Journal of Educational Psychology*, *86*, 389-401.
Moreno, R. & Mayer, R.E. (1999). Cognitive principles of multimedia learning: The role and modality and contiguity. *Journal of Educational Psychology, 91*, 358-368.
Paivio, A. (1971). Imagery and Verbal Processes. New York, NY: Holt, Rinehart & Winston.
Paivio, A. (1991). Dual coding theory: retrospect and current status. *Canadian Journal of Psychology,* 45, 255-287.
Posner, G.J., Strike, K.A., Hewson, P.W. & Gertzog, W.A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education*, *66*, 211-227.
Rieber, L.P. (1996). Animation as a distractor to learning. *International Journal of Instructional Media*, *23*(1), 53-57.
Schoenfeld-Tacher, R., Jones, L. L. & Persichitte, K. A. (2001). Differential effects of a multimedia goal-scenario to teach introductory biochemistry – who benefits most? *Journal of Science Education and Technology*, *10*, 305-317.
Sperling, R. A., Seyedmonir, M., Aleksic, M. & Meadows, G. (2003). Animations as learning tools in the authentic science materials. *International Journal of Instructional Media*, *30*, 213-221.
Spiro, R.J. & Jehng, J.C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear

and multidimensional traversal of complex subject matter. In: Nix, D., Spiro, R.J. (eds.) Cognition, education and multimedia: Exploring ideas in high technology, pp. 163–205. Lawrence Erlbaum Associates, Hillsdale.

Tao, P.K. (2004). Developing understanding of image formation by lenses through collaborative learning by multimedia computer-assisted learning programs. *International Journal of Science Education*, *20*, 1171-1197.

Tenenbaum, G., Naidu, S., Jegede, O. & Austin, J. (2001). Constructivist pedagogy in conventional on-campus and distance learning practice: an exploratory investigation. *Learning and Instruction, 11,* 87-111.

Trumper, R. (1997). Applying conceptual conflict strategies in the learning of the energy concept. *Research in Science and Technology Education*, *5*, 1-19.

Wang, H. A. & Marsh, D. D. (2002). Science instruction with a humanistic twist: teachers' perception and practice in using the history of science in their classrooms. *Science & Education, 11,* 169-189.

Whitnell, R.M., Fernandes, E.A., Almassizadeh, F., Love, J., Dugan, B.M., Sawrey, B.A. & Wilson, K.R. (1994). Multimedia chemistry lectures. *Journal of Chemical Education*, *71*, 721-725.

Yore, L.D. (2001). What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal of Science Education, 5*(4). Online journal: http://unr.edu/homepage/crowther/ejse.

Yore, L.D. & Treagust, D.F. (2006). Current realities and future possibilities: Language and science literacy—empowering research and informing instruction. *International Journal of Science Education, 28*, 291-314.