DOCUMENT RESUME

ED 476 701 SE 067 860

AUTHOR	Chang, Wheijen
TITLE	The Rewards and Challenge of Teaching Innovation in University Physics: Four Years Reflection.
PUB DATE	2003-03-00
NOTE	17p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Philadelphia, PA, March, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Academic Achievement; *Epistemology; Foreign Countries; Higher Education; Learning Processes; *Physics; Science Education; *Teaching Methods
IDENTIFIERS	Taiwan

ABSTRACT

This paper reports the transition of the researcher's teaching before and throughout teaching innovation, including one year traditional teaching (1996) and three years constructivist teaching (1999-2001). Based on the constructivist view of learning, an innovative teaching program was designed and implemented by the author in a university physics course in Taiwan. Learning outcomes of each year were evaluated by both academic tests and student questionnaire survey. Results indicated stagnation and the students' criticism that the researcher had confronted at early stage of teaching innovation in contrast to the rewarding outcomes and students' positive appraisal during long-term implementations. The study revealed complex but promising natures of the innovative constructivist teaching. Continuous modifications based on students' feedback and comprehension of learning theories are required to achieve a successful teaching innovation. (Contains 24 references.) (Author)

The Rewards and Challenge of Teaching Innovation in University Physics：Four Years Reflection

Dr. Wheijen Chang

Institute of Optical Physics/ Feng-Chia University

Taiwan

Proceedings of the 2003 Annual Meeting of the National Association (NARST), Philadelphia, paper # 201233

Abstract

This paper reports the transition of the researcher's teaching before and throughout teaching innovation, including one year traditional teaching (1996) and three years constructivist teaching (1999-2001). Based on the constructivist view of learning, an innovative teaching program was designed and implemented by the author in a university physics course in Taiwan. Leaning outcomes of each year were evaluated by both academic tests and student questionnaire survey. Results indicated stagnation and the students' criticisms that the researcher had confronted at early stage of teaching innovation in contrast to the rewarding outcomes and students' positive appraisal during long-term implementations. The study revealed the complex but promising natures of the innovative constructivist teaching. Continuous modifications based on students' feedback and comprehension of learning theories are required to achieve a successful teaching innovation.

The Rewards and Challenge of Teaching Innovation in University Physics：Four Years Reflection

Introduction

In recent decades, the development of constructivist view of learning has promoted the innovation in science teaching, including the area of university physics. Despite the burgeoning reports on the encouraging outcomes from innovative teaching programs in university physics (eg., Gautreau & Novemsky, 1997; Meltzer & Manivannan,, 2002), this study found that a successful innovative teaching may need long term commitments and continuous modifications to achieve. Over-optimistic attitudes towards the outcomes of innovative teaching may result in unexpected challenge and dissatisfactory feedback.

The objective of this study is to evaluate students' academic achievement and their opinions towards teaching and learning before and throughout the innovation teaching program, which was designed and implemented by the researcher. Having been teaching for 12 years in university physics under uni-directional transmission approach, the researcher enrolled in a doctoral program in science education in 1997. In 1999, the researcher resumed her teaching position and started to implement an innovative teaching program based on constructivist view of learning in her university physics classes.

The data of this study comprised of four years of teaching, applying one year traditional teaching (1996) and three years constructivist teaching (1999-2001). Three dimensions of comparison were applied, including: 1. the researcher's teaching before and after teaching innovation, 2. the researcher's teaching and other physics professors' teaching, 3. the researcher's teaching throughout the three year innovative teaching practice.

The context of the current study was a year one university physics course for engineering at Feng-Chia University, a large private university in Taiwan. The university physics course was a two-semester course, consisting of 16 weeks each semester. The course included 3 hr/wk lectures and 3 hr/wk laboratories sessions, but there was no tutorial/recitation sessions for this course. The size of the lecture class was about 55-70 students. Most of the students came straight from high school. They were homogeneous in their ages (18-20) and previous study experiences. In the lecture classes, physics professors' major teaching task (including the researcher's prior teaching) involved explaining physics principles/concepts, followed by solving manipulating-type problems, and occasionally demonstrating corresponding experiments. The students were expected to listening lecture and copying notes in class and practice end-of chapter problems after class, and discussion in class was hardly seen . In Taiwan, this type of transmission teaching method is also prevalent in high school physics classrooms, thus the incoming students of university physics were likely to perceive the didactic teaching approach as normal.

Literature

The literature related to this study can be described in three parts:

Firstly, the innovative teaching design was based on personal and social constructivist views of learning, which indicate the crucial role of learners' engaging in cognitive processing as well as to participate in social practice when learning physics (Posner, Strike, Hewson & Gertzog, 1982; Hennessy, 1993; Salomon and Perkins, 1998). In addition to providing information/answers, teachers are also expected to provide abundant questions and time to stimulate students to think and discuss (Driver, Asoko, Leach & Scott, 1995; Roth, McRobbie, Lucas & Boutonne, 1997).

Secondly, the literature reported many innovative teaching programs in university physics based on constructivist view of learning (eg., Redish, 1996). Major features of these teaching programs are summarized as follows:

1. focusing on conceptual development rather than mathematical problems solving (eg, Gautreau & Novemsky, 1997; Heller & Hollabaugh, 1992; Sharma, Millar & Seth, 1999);
2. providing teaching time for discussion in forms of pairs (eg., Mazur, 1996; Meltzer, 2002), small groups, or/and whole class discussions (eg., Heller & Hollabaugh, 1992; Mills, McKittrick, Mulhall & Feteris, 1999);
3. Monitoring of learning processes and providing instant feedback to teachers, either by inexpensive stationery (eg., Meltzer & Manivannan,, 2002) or electronic equipments (eg., Beichner, et al., 2000).

In addition to introducing the design of their innovative teaching programs, many studies reported the outcomes of the teaching innovation both in academic and affection. Most studies noted that although their teaching innovation reduced derivations in traditional problems (in textbooks), their students' performance in solving problems were not worse than, or even superior to, their peers in traditional classes (eg., Crouch & Mazur, 2001; Gautreau & Novemsky,1997). Innovative students' performances in conceptual tests were mostly found to be significantly better than those of the traditional groups (Hake, 1998; Fagen, Catherine & Mazur, 2002). Meanwhile, the innovative teaching seemed to benefit their students' affective learning outcomes as well as attitudes towards learning physics (eg., Meltzer & Manivannan, 2002).

However, most of the teaching innovation programs in university physics reported in the literature were conducted in western countries. The results may not be directly transferable to the classrooms in Asia. Meanwhile, a few studies reported the outcomes of long term implementations of the innovative teaching (eg, Crouch & Mazur, 2001), yet the discussions did not focus on either the progression throughout the period or the challenge an education innovator may need to confront, especially during the early stage of implementation. The current study focused on the outcomes of the same instructor (researcher) before and throughout innovation processes at an Asian university.

Thirdly, the literature reported potential challenge and obstacles that instructors might need to confront regarding teaching reform. They were

1. the complexity in questioning while conducting inquiry-teaching (Meltzer & Manivannan, 2002). Roth (1998) found that both of the context and content of the responses and reactions to questions need to be taken into account while conducting inquiry-type questioning, which was a complex practice and cannot be appropriated easily. Meanwhile, the grasp of an appropriate extent and timing of intervention during discussion is very challenging (Bell & Gilbert, 1996);

2. mismatch of the innovative teaching design and existed assessment-orientation was found in many studies (Bell & Gilbert, 1996; Tsai, 2001);

3. students, who possess transmission view of learning, may regard the inquiry-type teaching as ineffective in terms of knowledge accumulation (Banerjee, Vidyapati & Vidyapati, 1997; Cottle & Hart, 1996; Mazur1996; Maclsaac & Falconer, 2002);

Bell and Gilbert (1996) suggested that in order to reinforce both of the students and the teachers a continued commitment to the ways of improvement in teaching and learning, enable them to experience "better learning" is important. The so-called "better learning" implies not only better academic performance, but forms a wider perspective, which includes greater enjoyment, social cooperation, ownership, confidence and motivation.

Design of the constructivist teaching

In this study, the innovative constructivist teaching provided about a quarter of the teaching time for the students to discuss conceptual questions by means of reducing the derivations of traditional problems. The reduction of solving problem in class was compensated by assigning textbook problems for the students to solve after class. Quick tests on the assignment were conducted to monitor the students' learning. The questions for group discussion were mostly embedded by everyday life contexts, and some were presented alone with demonstrations. About 6 to 10 questions were provided as a worksheet for the group discussion, which took 20 to 30 minutes to discuss. While grouping, the researcher firstly assigned one third of the top students as the "seeds" of each group and allowed two other students to join the group. During the group discussion, the researcher assigned several groups to write their answers on the blackboard. Then all the students were encouraged to voluntarily correct the answers on the board. Answers of the assigned groups were not graded, while the voluntary students who made right corrections received credits. The researcher then took 15 to 20 minutes to review the answers and the related theories.

Methodology

The outcomes of the teaching program were evaluated by the student questionnaire survey and the standardized tests.

The questionnaire included both closed and open-ended questions. In addition to quantitative evaluation of the outcomes of the researcher's innovative teaching program, qualitative responses in the open-ended questions provide insight for modifications of further implementation. Closed questions included the students' self-evaluation of their learning achievement and their perceptions of the teaching performance. Open-ended questions investigated the students' opinions of the strengths and weaknesses of the teaching design. Both the researchers' and her colleague's (physicists') year one students participated in every survey. Participants of each year/group varied from 46 to 141, with the total participants being 362 (researcher's) and 494 (physicists').

To encourage participation and honesty in responses, the anonymous survey was conducted after the course was finished of the academic year by research assistances.

In order to examine the students' academic achievement during the course, the researcher translated two standardized tests, Force Concept Inventory (FCI)(Hestenes, Wells & Swackhamer, 1992) and Mechanics Baseline Test (MBT)(Hestenes & Wells, 1992). The split-half reliabilities of the two tools were around $r = 0.72$ after

Spearman-Brown modification. Four innovative classes taught by the researcher and four conventional classes taught by three physicists were examined. About 50-60 students in each class completed both pre-test and post-test.

Results

The outcomes of the researcher's teaching can be described in three areas: 1. comparison of academic performance between the students of innovative teaching and traditional teaching, 2. quantitative analysis of closed questionnaire survey, and 3. qualitative analysis of open-ended questions.

Firstly, the results of the students' performance in the two standardized tests are tabulated in Table I. Gain percentage was utilized to examine the students' academic achievement during learning university physics, which is defined as (posttest–pretest)/(100–pretest), indicating the ratio of what has been gained to what have been unlearnt (Hake 1998). The literature indicated that gain% can be independent to the students' background (Savinainen & Scott, 2002).

Table I: Comparison of the students' academic achievement in conventional classes and the innovative classes

	Conventional Teaching				Innovative Teaching			
Tests	Yr (physicists)	Pre test	post test	Gain%	Yr (researcher)	Pre test	post test	Gain%
FCI	2001(A)	60.9	64.6	5	2001(R**)	62.6	68.7	12
	2001(B)	70.2	67.3	5	2001(R)	63.8	73.4	23
MBT	1997(A)	48.6	51.2	5	2000(R)	45.0	51.9	13
	1997(C)	52.8	56.8	9	2000(R)	50.9	63.0	25

* A, B, C: three different physicists' teaching in conventional classes,
**R: innovative teaching program implemented by the researcher.

Table I showed that the gain percentages of the four conventional classes, varied from 5% to 9%, with most classes received as low as under 10%. In contrast, the gain percentages of the four innovative classes varied from 12% to 25%. The data obtained from the two consecutive year of innovation teaching may be insufficient to make any assertion regarding the progression throughout the process. Despite the fact that the gain percentages of both groups found in this study appeared to be lower than those reported from western countries in the literature (eg., Hake, 1998), the innovative teaching program seemed to provide light for improving the disappointing outcomes found in conventional classes.

Secondly, the students' perceptions of how they have learnt and how their teaching had performed in the closed questionnaire survey have been analyzed. Opinions of the researcher's students, in both traditional teaching (1996) and innovative teaching (1999-2001) were compared with the physicists' students respectively. One-tail t-test was adopted to evaluate the statistical significance, and the probabilities of the t-test are listed in Table II.

Table II: Perceived learning outcomes: Probability of one-tail t-test comparing the researcher's and other physicists' teaching

Researcher's teaching	traditional	Innovative	teaching	
Year	1996	1999	2000	2001
(N, researcher's : physicists')	(77:125)	(46:113)	(106:115)	(143:141)
physics concept comprehension	*0. 0086	0. 031	**3E-04	0.0296
knowledge for advanced study	*0. 0021	0. 78	*0.003	0.131
mathematical ability	0. 0954	(-)**5E-04	0.253	0.373
application in everyday life	0. 4224	**2E-06	**4E-04	**7.96E-07
thinking/reasoning ability	0. 4831	0. 052	**2E-04	*0.00893
flexible/deep learning strategies		*0. 003	**2E-07	**3.99E-04
interest in learning physics	0. 0673	0. 018	**4E-06	**2.44E-04

*p<0.01 **p<0.001

During traditional teaching in 1996, the researcher's teaching seemed to benefit to her students in the development of physics concept and knowledge, when compared to those of her colleagues' teaching. However, under similar teaching approach, the researcher's teaching seemed to help just as much as her colleagues in developing learning ability and learning attitudes.

The situation in the first year of teaching innovation in 1999 has been changed drastically. The prior strengths found in the researcher's teaching in developing students' physics knowledge were absent. The researcher's students seemed to learn more in application of everyday life but gain less in mathematical ability comparing with their peers in physicists' classes. The results may reflect the modifications of the innovative teaching design which reduce mathematical derivations and introduce more everyday life examples. Despite the efforts that the researcher had put on introducing an abundant of contextualized conceptual questions and organizing groups to stimulate the students' thinking and discussion, the expected outcomes of conceptual comprehension, thinking ability, and interest in physics, were not significantly superior to those of the conventional classes.

In 2000, the second year of innovative teaching, the researcher had made several modifications of the curriculum design. On one hand, the researcher proposed the abandon of the unified syllabus/examination system as well as expressing stricter attitudes in managing students, eg., roll-calling and assignment tests. On the other hand, the researcher continuingly developed contextualized conceptual questions and persisted on the conduction of group discussion in class. The learning outcomes of the second year innovative teaching appeared to improve significantly in most aspects, including physics concepts and knowledge, thinking ability, flexible learning strategies, and interest towards learning physics. Meanwhile, the strategy of reducing solving problems seemed not to hurt to the students' mathematical ability comparing with their peers in conventional class.

Due to the supportive results found in the year 2000, the third year innovation teaching was mostly kept the same as that of the previous teaching, and the evaluation results in 2001 were similar to those of year 2000.

In addition to the self-evaluation of their learning, the study investigated the students' perceptions of teaching performance, and the results were listed in Table III.

Table III: Perceived Teaching Performance: Probability of one-tail t-test comparing the researcher's and the physicists' teaching

Researcher's teaching	traditional	Innovative teaching		
Year	1996	1999	2000	2001
(N, researcher's : physicists')	(77:125)	(46:113)	(106:115)	(143:141)
Knowledge in physics	0. 356	0. 037	0.357	0.185
Pedagogical knowledge basis		0. 572	0.253	0.0822
Introducing everyday life examples	0. 065	0. 086	**3E-06	**2.2E-10
Encouraging discussion in class	0. 293	**3E-08	*0.003	**2.4E-18
Lucid lecture	*0. 0043	0. 463	*0.006	*0.00289
Being aware of learning outcomes		0. 421	**2E-04	**2.45E-04

*p<0.01 **p<0.001

Table III showed that features of the researcher's teaching perceived by her students varied dramatically before and throughout the teaching innovation. Before innovation, in 1996, the only strength that the researcher's students praised to her teaching was providing lucid lecture comparing with her colleagues' teaching. However, during her first year of teaching innovation in 1999, the strength of the researcher's teaching seemed to deteriorate, while the students noticed the efforts that the researcher had put on encouraging discussion in class. This teaching strategy had always become a noticeable feature to the researcher's students during the three year innovation. The second year teaching innovation in 2000 seemed to receive high appraisal from the students in most aspects of teaching performance, and the positive responses appeared similarly in year 2001 again. One thing need to be noted here that despite the fact that the researcher was the only instructor majored in the area of science education, the students seemed not to notice the researcher's strength on pedagogical knowledge basis. This implied that the students in innovative teaching put their appraisal on the curriculum and teaching style rather than the personal characteristics of the instructors. Table II and III showed that the students' perceptions of how they had learnt and how the teachers had performed seemed to reflect fairly well to each other.

Finally, the students' comments towards the researcher's teaching in open-ended questions were analyzed in Table IV, which is discussed in four aspects as following:

Table IV: A comparison of the students' comments towards the researcher's teaching before and throughout innovation

	Traditional (1996, N=54)	Yr1 innovation (1999, N=41)	Yr 2 innovation (2000, N=80)
strengths			
Lucid lecturing	18 (33%)	2 (5%)	8 (10%)
Encouraging discussions	1 (2%)	14 (34%)	20 (25%)
Everyday-life examples	19 (35%)	29 (71%)	33 (41%)
Inspiring/thinking	3 (5%)	8 (20%)	11 (14%)
Interest	3 (5%)	2 (5%)	8 (10%)
weaknesses			
Incapable teaching	0	12 (29%)	6 (8%)
more life examples/reduce math	17 (31%)	1 (2%)	7 (9%)
Boring/tiring	7 (13%)	3 (7%)	3 (4%)
Inappropriate management	4 (7%)	11 (27%)	9 (11%)
Course impractical/useless	5 (9%)	0	0
Extend teaching time	0	0	5 (6%)

(1) lucid lecture or incapable teaching

While traditional teaching, the highest appraisal from the researcher's students to her teaching was providing lucid lecture. However, in the first year innovation teaching, the students were found to possessed opposite perceptions towards the researcher's teaching. Incapability in teaching performance became the highest concerns from the researcher's students. Twelve out of 54 students expressed their criticisms towards the researcher's lecturing skills/design, which included vague interpretations, unsystematic structure, untidy in board-writing, key points absent, irrelevant examples, no unified teaching method, teacher not professional...etc. The results implied that while an innovative teacher put more awareness on students' learning engagement/process, the teaching performance might deteriorate in turn. The incapability of teaching performance may become a noticeable problem to the students who possess transmission view of learning.

The results provided the researcher a sign of warning leading her to put more efforts on lecturing performance. In the second year, the problem of lecturing appeared to be mentored with more preparation efforts as well as the accumulation of teaching experiences.

(2) interactive or didactic

Introducing conceptual questions to engage students in group discussion was one important strategy of the innovative teaching. This feature in innovative teaching received many students' positive responses in contrast to only one response in traditional year. Meanwhile, the traditional students seemed not to concern about the absent of student discussion in class. Without experiencing an interactive teaching, the traditional students may regard the didactic teaching as normal, and encouraging discussion seemed not to be an issue of concern.

(3) real examples or irrelevant theories

The conceptual questions for group discussion were mostly embedded in contexts of everyday life in the innovative teaching. The feature received the highest praise from the innovative students in both years. In traditional year, although many students pointed out their affection towards the introduction of real examples, strong expectations of providing more examples were proposed. Thus, this issue seemed to receive most students' concern regardless of their learning experiences.

(4) boring or inspiring

The traditional students' appreciation towards the researcher's teaching on providing lucid lecturing seemed not to result in their engagement in learning. On the contrary, the feeling of boredom and tiring appeared to be a major problem of the traditional students. The problem of lack of learning engagement was dramatically overcome by innovative teaching. In both of the innovative teaching years, significantly less students felt bored and more students felt inspiring/thinking provoking comparing with those of the traditional year. The strategies of introducing life examples and group discussion may play a crucial role on engaging students' thinking/learning.

(5) student management

Comparing with the traditional group, the innovative students expressed higher concerns on the inappropriate student management from the researcher. More responses as well as multiple-dimensional criticisms were raised towards the innovative teaching in the aspect of student management comparing with those of the traditional. The innovative group's concerns included threshold of passing, class order, calling attendance, mismatch between teaching and examination, while the traditional group merely focused on threshold of passing. Comparing with the traditional didactic teaching, innovative constructivist teaching may focus more on monitoring students' learning engagement, in-class and out-of-class. The low standard of student management of the whole university may become a barrier to the researcher's student management.

(6) value of the course

The last is the students' perceptions of the value of taking the course. In traditional year, five students complained about the impracticalness of the course and/or argued against the existence of the course. On the other hand, the second year of innovation, five students complained about the shortage of teaching time and/or asked for extension of the teaching time. The "complaint" of the latter group implied their appreciations of the value of the course, which can be regarded as compliment rather than criticism to the innovative teaching.

Conclusion and Discussion

In conclusion, during traditional teaching (1996), the researcher's students expressed their appreciation towards her teaching on providing lucid lecture but still felt a sense of boredom during the course. Although more of the researcher's students agreed with the development in physics concepts and knowledge when compared with other physicists' students (found in closed questions), the course seemed to be unsuccessful in engaging students in thinking and learning in class (implied from the open-ended questions).

When the researcher attempted to improve learning by implementing the first year innovative constructivist teaching (1999), the outcomes appeared to be far under the researcher's expectations. Although the researcher's students noticed the two strategies of the innovative teaching, ie, providing real examples and encouraging discussions (showed in both open-ended and closed questions), the teaching strategies seemed not to lead to the expected learning outcomes in developing students' conceptual comprehension, learning ability, and attitudes towards learning physics. The innovative students even argued against the researcher's teaching proficiency, which used to be a major strength praised by the prior students. In other words, the first year innovative teaching failed to fulfill the objectives in constructivist perspectives while losing the existed strength of transmission perspectives. The dissatisfactory results revealed the profound challenge and risks innovative teachers might confront.

Reflecting from the unsuccessful innovative experiences, the researcher made several efforts to overcome the possible barriers as well as modify her teaching as to be more suitable to the students, which will be discussed later. The outcomes of the second year innovative teaching (2000) improved dramatically. Most of the researcher's students appreciated and praised the features of the teaching design (closed questions), and many students made links from teaching design to their learning engagement (open-ended questions). Learning outcomes, both in academic achievement and attitudes towards learning physics, of the researcher's class were found to be significantly better than those of other physicists' classes. In spite of the encouraging results found from the majority of students, minor but real criticisms remain exist. Teaching styles and student evaluation criteria became the main concerns of these skeptical students (found in open-ended questions). Maintenance of the positive learning outcomes and elimination of the minor skepticism were the objectives for ongoing teaching.

The outcomes of the third year teaching innovation (2001) appeared to be similar to that of the second year innovation. Although the innovative class seemed to perform better than other physicists' classes in academic tests, there were no signs of improvement from the researcher's students during the two consecutive years. The gain percentages in academic tests of the innovative students remained lower than those reported by western programs, which is a goal to pursue for the researcher in ongoing teaching.

Throughout the three years of innovative teaching, the researcher gradually comprehended the challenge and barriers of a constructivist teacher may confront. Many efforts need to be in place to achieve a successful teaching innovation. Suggestions to potential innovative teachers are discussed as follows:

1. Demands of teaching performance and preparations

The demands for innovative teachers in teaching performance are much higher than those for traditional teachers (Bell and Gilbert, 1996, p.112; Meltzer& Manivannan, 2002). In order to conduct a successful session, innovative physics teachers may need to search for related real examples, embed the examples into discussion questions, set up equipment and practice demonstration, cultivate supportive atmosphere to promote the participation of discussion, and organize teaching sequence to allow the continuity of the discussion and instructions… etc. All these efforts may harm the performance of innovative teachers in giving lucid lecture, which may be the single major task for traditional teachers. Meanwhile, in order to inspire the students' thinking and discussion, innovative teachers need to provide their students with novel and open questions, which may, in turn, stimulate a wide range of novel answers and/or questions from the students. It may be challenging for the teacher to respond to these answers/questions immediately in front of the class. All of these "extra" demands may harm the teaching performance in the transmission perspective and even challenge to the teachers' professional capability.

2. Consistency of teaching and assessment design

The innovation teaching program not only modified the model of teaching and learning in class, but also shifted the criteria of learning achievement. In accordance with the rationale of literature in physics education (eg, Gautreau & Novemsky, 1997; McDermott, 1993), the researcher's innovative teaching focused on conceptual comprehension rather than mathematical skills. However, a unified examination system, which is dominated by traditional problems, had resulted in the mismatch between what the researcher had taught and what the students should learn. With the researcher and several of her colleagues' efforts, the over 10 years unified policy was finally abandoned in 2000. The unified system may contribute to the unsatisfactory outcomes of the first year innovation, where many students complained about the mismatch between teaching and assessing (in open-ended questions).

3. Impact of the existed culture in the teaching contexts

The culture of the teaching contexts may also exert impact to the outcomes of the innovative teaching. Didactic way of teaching still dominates most of the physics classes in Taiwan, and the previous learning experience may impede the students' acceptance to the innovative teaching design. Some students may argue against the effectiveness of the novel teaching, when the teachers stop lecturing to engage learning practice. A few students wondered why bothered listening to peers' wrong answers instead of the teacher's correct answers. Meanwhile, after six years of intensive pressure on high school studies, many Taiwanese university students possess negative attitudes towards the new stage of studies. The passive attitudes towards university study become another barrier impeding the outcomes of innovative teaching, which normally require more learning engagement in class and out of class.

4. Careful usage of grade incentive

Grade incentive can be an effective tool to enforce learning commitment, but too much emphasis on grades may undermine students' intrinsic learning motivations in (Trigwell and Prosser, 1991). The rule of using grade incentive is closely determined by students' learning attitudes. At the early stage of the first year innovative teaching, the researcher intentionally reduced the role of grading while teaching, to avoid deterioration of interest towards learning physics. While depressingly, the strategy was found to be inappropriate to many of the students, who were not prepared to learn conscientiously at the beginning and were eventually totally absent in class eventually. Unfortunately, it was found too late to modify the researcher's attitudes in managing students after the first impression has been established in the students' mind. Reflecting from the unsuccessful year, the researcher increased the role of grades in the following years, which were found to be fairly appropriate to the current students.

In summary, throughout the four years of teaching, this study has indicated the encouraging outcomes successful innovative teaching may achieve, However, multiple-dimensional challenge and barriers may need to be overcome before obtaining the achievement. Improvement of teaching and learning may need long-term commitments and persistence.

Reference

Banerjee, A. , Vidyapati, A & Vidyapati, T. (1997). Effect of lecture and coorperative learning strategies on achievement in chemistry in undergraduate classes. *International Journal of Science Education, 19*(8), 903-910.

Beichner, R., Saul, J., Allain, R., Deardorff, D. & Abbott, D. (2000). Introduction to SCALE UP: Students-Centered Activities for large enrollment university physics. *Proceedings of the 2000 Annual meeting of the American Society for Engineering Education.*

Bell, B & Gilbert, J. (1996). *Teacher Development*. London: Falmer press.

Cottle, P & Hart, G. (1996). Coorperative learning in the tutorials of a large physics class. *Research in Science Education, 26*(2), 219-231.

Crouch, C. H. & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970-977.

Driver, R., Asoko, H. Leach, J. & Scott, P. (1995). Constructing scientific knowledge in the classroom: a theoretical perspective on pedagogy. *Paper Presented at AERA Annual Meeting*, San Francisco.

Fagen, A., Catherine, C. & Mazur, E. (2002). Peer Instruction: Results from a Range of Classrooms. *The Physics Teacher, 40,* 206-209.

Gautreau, R & Novemsky L. (1997). Concepts first-A small group approach to physics learning, *American Journal of Physics, 65*(5), 418-428.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses, *American Journal of Physics, 66*(1), 64-74.

Heller, P. & Hollabaugh, M. (1992). Teaching problem solving through cooperative grouping. Part2: Designing problems and structuring group. *American Journal of Physics, 60*(7), 637-644.

Hennessy, S. (1993). Situated cognition and cognitive apprenticeship: implications for classroom learning. *Studies in Science Education, 22,* 1-41.

Hestenes, D. & Wells M. (1992). A mechanics baseline test. *The physics Teacher, 30* (3), 159-166.

Hestenes, D., Wells M. & Swackhamer, G. (1992). Force concept inventory. *The physics Teacher, 30*(3), 141-158.

Mazur, E. (1996). *Peer Instruction: A Users' Manual.* Upper Saddle River, NJ, Prentice Hall.

McDermott, L. (1993). How we teach and how students learn- A mismatch? *American Journal of Physics, 61*(4), 295-298.

Meltzer, D. & Manivannan, K. (2002). Transforming the lecture-hall environment: The fully interactive physics lecture. *American Journal of Physics, 70*(6), 639-654.

Mills, D., McKittrick, B., Mulhall, P., & Feteris, S. (1999). CUP: cooperative learning that works. *Physics Education, 34*(1), 11-15.

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*(2), 211-227.

Redish, E. F. (1996). New models of physics instruction based on physics education research.[WWW document]. URL http://www2.physics.umd.edu/~redish/redish/htm

Roth, W. M., McRobbie, C. J., Lucas, K. B. & Boutonne, S. (1997). Why may students fail to learn from demonstrations? A social practice perspective on learning in physics. *Journal of Research in Science Teaching, 34*(5), 509-533.

Salomon, G. and Perkins, D. (1998). Individual and social aspects of learning. *Review of Research in Education, 23*, 1-24.

Savinainen, A. & Scott, P. (2002). The Force Concept Inventory: A tool for monitoring student learning. *Physics Education, 37*(1), 45-52.

Sharma, M., Millar, R. & Seth, S. (1999). Workshop tutorials: Accommodating student-centered learning in large first year university physics courses. *International Journal of Science Education, 21*(8), 839-853.

Trigwell, K. & Prosser, M. (1991). Improving the quality of student learning: the influence of learning context and student approaches to learning on learning outcomes. *Higher Education, 22,* 251-266.

SE067869

ERIC®

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: The Rewards and Challenges of Teaching Innovation in University Physics : Four Years Reflection	
Author(s): Chang, Wheijen	
Corporate Source: Proceedings of the 2003 Annual Meeting of the National Association for Research in Science Teaching, Philadelphia (paper # 201233)	Publication Date: March, 2003

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Wheijen Chang	Printed Name/Position/Title: Wheijen Chang / Associate Professor / Dr.	
Organization/Address: Physics Teaching Center, Feng-Chia University P.O. Box 25-215, Taichung, Taiwan	Telephone: 886-4-24517250-5065	FAX: 886-4-24510182
	E-Mail Address: wjchang@fcu.edu.tw	Date: 12/May/2003

(over)