



Equal opportunity tactic: Redesigning and applying competition games in classrooms

Hercy N.H. Cheng^{a,*}, Winston M.C. Wu^b, Calvin C.Y. Liao^b, Tak-Wai Chan^b

^a Department of Computer Science and Information Engineering, National Central University, No. 300, Jhongda Road, Jhongli City, Taoyuan County 32001, Taiwan, ROC

^b Graduate Institute of Network Learning Technology, National Central University, No. 300, Jhongda Road, Jhongli City, Taoyuan County 32001, Taiwan, ROC

ARTICLE INFO

Article history:

Received 7 January 2009

Received in revised form 1 May 2009

Accepted 4 May 2009

Keywords:

Elementary education
Evaluation of CAL systems
Pedagogical issues

ABSTRACT

Competition, despite its potential drawbacks, is an easily adopted and frequently used motivator in classrooms. Individual abilities, in the years of schooling, are inevitably different, and performance in competition is heavily ability dependent, resulting that more-able students always win while less-able students always lose. Students easily perceive how well they perform through the result of competition, which is termed as perceived performance in this paper. Consistently demonstrating lower perceived performance than their peers, the less-able students feel discouraged and frustrated, hardly having the same opportunity for owning the sense of achievement as the more-able students. In this study, the authors designed a computerized mechanism, equal opportunity tactic, to lessen the difference in perceived performance between more-able and less-able students. Equal opportunity tactic is incorporated into a version of a competitive learning game called AnswerMatching, in which every student is assigned an opponent with similar ability. An experiment was also conducted to preliminarily investigate the effectiveness and effects of the tactic. Results showed that equal opportunity tactic could reduce the effect of individual ability difference on the perceived performance as well as the belief about how well students could achieve. In other words, less-able students could have similar opportunity of success and build confidence similar to more-able students in a competition.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

Competition in classrooms is an activity of comparing relative performance of all students and rewarding the best students in the end (Marsh & Craven, 1997). A recent research showed that competition can easily elicit contrast effects (Stapel & Koomen, 2005), a mindset in which the differences between self and the others are spotlighted. In other words, when students are situated in a competitive context with higher-performance students, their attention are focused on the difference in performance and they tend to regard themselves as worse performers. Furthermore, many researchers have showed that there is a strong and positive correlation between performance and ability belief, such as self-efficacy (Bandura, 1997; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Collins, 1982; Pajares & Kranzler, 1995), expectancy for success (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), perceived ability (Greene & Miller, 1996), and so forth. The students who believe they can do well tend to perform better in learning tasks; and performance will further but indirectly shape the ability belief. Competition, which emphasizes the performance a lot, may undermine the performance of those who have low ability belief when they lose (Bandura & Locke, 2003). Therefore, in a competition the students having high performance are usually more confident of their ability but the students with low performance often feel more depressed, frustrated, or inferior. Even worse, their self-esteem may be also impaired (Kohn, 1992).

When participating in a competition, students are exposed to a big deal of social comparison messages, which may influence their self-conception, emotions, and actions (Gilbert, Giesler, & Morris, 1995; Mussweiler, 2003). The sources of such messages come from not only teachers but also peers' performance (Levine, 1983). Even in a learning environment where rankings of ability and grade are explicitly minimized, the behavior of comparing performance still occurs (Crocker & Bryant, 1978; Hechinger & Hechinger, 1974). In most learning activities including competition, people believe that performance is a direct outcome of ability. In fact, performance describes a relative relation between ability and task difficulty. Furthermore, if the task is relatively easy for a student, the performance will be higher than if the task is difficult or challenging. Because the learning task in a classroom is usually the same to all students, their performance

* Corresponding author. Tel.: +886 3 422 7151 35406; fax: +886 3 426 1931.
E-mail address: hercy@CL.ncu.edu.tw (H.N.H. Cheng).

explicitly indicates how able or unable they are. Even though the performance is not open to the other students, they are still aware of the ability ranking. As a result, less-able students will realize their actual ability with the hint of their performance. Usually, the performance ranking of all students in a classroom is static and unchanged. In other words, less-able students can hardly have the same opportunity for performing well and owning the sense of achievement as more-able students.

Although competition has so many drawbacks, it is also a frequently used activity in classrooms as well as in schools. The reason perhaps is that competition, besides drawing attention and excitement, is a well-structured activity with a clearly defined goal for students. If the negative effects described above could be mitigated, competition could be a motivator for excelling oneself. The objective of this research is to design a computerized mechanism, *equal opportunity tactic* (EOT), for moderating the difference in the opportunity of performing well between more-able and less-able students in a competition.

2. Equal opportunity tactic

2.1. Redefining performance

In many psychological theories, there are several definitions about confidence or belief in one's ability. One of the fundamental constructs is self-efficacy (Bandura, 1977, 1997; see also Zimmerman, 2000), which was defined as one's judgment of ability to solve a problem. People with low self-efficacy feel that things are more difficult than they really are. Bandura (1986) also distinguished self-efficacy from *outcome expectations*, beliefs of the causal relations between certain actions and outcomes (e.g. believing that practicing will improve one's performance). That is to say, self-efficacy assesses confidence in terms of attributing one's performance-related belief to ability rather than actions. Furthermore, self-efficacy has been proved to predict subsequent behavior and performance. For example, people with high self-efficacy tend to choose challenging tasks, even works about their career (Bandura, 1997; Bandura et al., 2001). Collins (1982) reported that students with high self-efficacy solved more problems successfully, regardless of ability. In addition, if they found some problems were missed, they tended to rework those problems.

Another underlying belief is *expectancy for success* (Eccles et al., 1983), defined as beliefs about how well one would do on upcoming tasks. Several longitudinal studies have confirmed that expectancy for success has an influence on and can even help predict one's future performance and achievements (Eccles, 1987; Eccles et al., 1983; Eccles, Adler, & Meece, 1984; Eccles & Wigfield, 1995; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Meece, Wigfield, & Eccles, 1990; Wigfield et al., 1997). Wigfield and Eccles (2000) also argued that expectancy for success is essentially similar to self-efficacy rather than outcome expectations. However, there is a psychometric difference between self-efficacy and expectancy for success: self-efficacy is usually measured by a questionnaire item like "how confident are you of doing something" (see Pajares, 1996) whereas expectancy for success is measured by "how well do you expect to do something" (Wigfield & Eccles, 2000). In other words, expectancy for success assesses confidence in terms of predicting the final results instead of asking one's perception of ability.

Eccles and her colleagues (Eccles et al., 1983; Eccles & Wigfield, 2002; Meece et al., 1990) also built *expectancy-value model* to illustrate the relations among several social cognitive variables and performance. In this model, expectancy and values are assumed to directly influence performance, while expectancy is assumed to be influenced by *perceived ability*, one's self-rated ability. Moreover, perceived ability influences meaningful cognitive engagement in preparing midterm and final performance (Greene & Miller, 1996). However, performance is not only the result, but also the cause of shaping one's confidence or belief in ability. The expectancy-value model also showed that the performance which results from one's choices and actions will become parts of their achievement-related experience, and indirectly influences future perceived ability and expectations.

It should be noted that although most students believe that performance is an indication of ability, it shows only how well one is doing tasks, not necessarily how able one is. Some forms of performance are actually influenced by task rules besides ability, for example, task design, resources, collaborators or opponents. To be precise, there are at least two categories of performance: *perceived performance* and *actual performance*. This paper defines perceived performance as a clear-cut result that one receives after one solves a task (e.g. the grade or score of homework). Perceived performance can be influenced by task rules. For example, the test scores would be changed if the rules stipulated that scores should be deducted for wrong answers. Actual performance is defined as a measure of describing one's process of solving a task (e.g. one's correctness or response time in homework). Actual performance could be regarded as an indication of one's ability to solve a certain task (e.g. mathematical proficiency; Kilpatrick, Swafford, & Findell, 2001).

Both actual and perceived performance may shape one's confidence. For example, while doing homework, a student solves the problems correctly and fast (actual performance). The actual performance is so high that his confidence could be built during the process. After he receives a high grade (perceived performance) on the homework, the grade can also enhance the confidence. Although actual performance provides more useful information on the learning progress, perceived performance is usually designed as a kind of goal to pursue. Therefore, people attach importance to perceived performance, care about it and are willing to make efforts for it, especially in a competitive environment. People may work harder with a positive expectancy for better perceived performance.

Although actual performance is mainly determined by ability, perceived performance is influenced by the activity design besides ability. In other words, changing any parts of an activity changes perceived performance as well. For instance, suppose two players are playing bowling. If the scoring rules of a strike (knocking down all ten pins with the first ball) were changed from additionally doubling the next two scores to doubling the current score, it would thus change both players' scores and possibly change the winner. Alternatively, if we regarded the opponent as a part of the activity and changed an opponent to compete, the scores would be different, too. Because it is not easy to change one's ability and actual performance in a short time, nor easy to moderate the ability difference, this study focuses on changing one's perceived performance by manipulating the activity design.

2.2. Redesigning learning tasks

The rules of most learning activities are intentionally designed to link actual and perceived performance, so that the perceived performance can represent the actual performance and explicitly show the level of ability. Furthermore, in a mixed-ability class, consisted of

heterogeneous students, the ability difference is considerable and evitable. Less-able students cannot catch up with more-able students. Because perceived performance becomes information of ability, less-able students reinforce their beliefs that they are “worse.” The confidence of less-able students is eventually hurt while more-able students build their confidence. However, if less-able students could be situated in an equal opportunity environment that their perceived performance is not lower than that of more-able students, these less-able students would become as confident as those more-able students. Therefore, this study propose redesigning all learning tasks to re-shape students’ confidence by providing equal opportunity of acquiring similar perceived performance. That is, the designers of learning activities have to unlink the perceived and the actual performance in rules.

Equal opportunity does not mean to adopt chance games, in which the main cause of success is luck and each player expects that he will win eventually even if the chance is slim. Rather, the authors argue that the factor of luck weakens the relation between efforts and outcomes, and may undermine students’ interests in learning. A previous study which involved a change game for practicing arithmetic (Cheng, Deng, Chang, & Chan, 2007) found that even if most subjects were engaged in playing and practicing, there were still a few high-performance students starting to do mischief after a while. These subjects reported that they felt more and more bored because they realized luck was the major cause of their victories or defeats rather than their efforts, implying that students care about paying efforts to win. It is true that luck can help students attribute their losses to the game instead of themselves, but it also stops them from endeavoring more and excelling themselves at the same time. Hence, besides unlinking perceived and actual performance, the designers should not link up perceived performance with the factor of luck, either.

From the perspective of activity design, perceived performance can be affected by the relation between ability and task difficulty. If a student faced a harder task than he could solve, he would get a low perceived performance and feel frustrated; otherwise, he would get a high perceived performance, finding the task too easy and boring. In a classroom where mixed-ability students learn, the same learning task could not satisfy all students. It is a problem not only about cognition, but also about affective status in learning. However, if every student could receive a suitable and unique learning task on the basis of his ability, his perceived performance would be similar to the others’ and his confidence could be built. Additionally, when the current ability matches the difficulty of the learning task, students may feel engaged in the task without boredom and frustration (Csikszentmihalyi, 1975, 1990). In other words, EOT is to assign every student a tailor-made learning task that could foster beliefs in ability, so that all students could have equal opportunity to have similar perceived performance. In EOT condition, perceived performance does not represent the ability any more, but is an outcome of making efforts to solve the task.

Furthermore, EOT needs to understand each student’s ability and to adjust some parts of the task to the unique ability. However, it is difficult for teachers to adopt EOT in a classroom without computer supports, because they are usually too busy at teaching and handling tedious works to deal with individual requirements. In the research area of adaptive learning systems (see reviews in Brusilovsky, 1999; Brusilovsky & Peylo, 2003), there have been many technologies developed for facilitating individual learning by establishing an optimal learning environment, for instance, adaptive curricular sequence (e.g. CALAT; Nakabayashi, Maruyama, Koike, Fukuhara, & Nakamura, 1996), presentation of content (e.g. ActiveMath; Melis et al., 2001), solution feedbacks (e.g. SQL-Tutor; Mitrovic, 2003), and so forth. Computers thus can play a role of helping teachers take care of every student owing to its capability to record and exchange information immediately. While students are interacting with their personal computers, their actual and perceived performances can be recorded as learning portfolios, which can be further used to estimate their abilities, for example, knowledge, the structure of concepts, procedural skills, and so forth. Moreover, on the basis of the estimated abilities, parts of the learning task can be adjusted appropriately by the technologies of adaptive learning. While those existing technologies attempt to relieve cognitive loads for individual learning, EOT focuses on how to build confidence and arouse positive affective status in a social environment.

Although computers are good at displaying almost all kinds of information, some information might hurt students. When designing EOT, the designers should consider this information carefully. If the information related to actual performance is open to the others, the confidence of less-able students would be harmed. Such information should be hid and limited only to the teacher and the student himself. Besides, the names of opponents could be the information of actual performance. Students have preconceptions about their classmates and could be aware of their relative abilities. Research also suggests that anonymity is helpful to increase students’ preference for the classroom climate in a competitive activity (Yu, 2003). In addition to the information related to actual performance, explicitly adjusting tasks may also hurt less-able students. If they found that their assigned tasks are visibly different, they would possibly dislike and refuse to do the learning activities. Therefore, the fundamental principle of adopting EOT is to hide the actual performance and the tactic itself.

2.3. EOT design for competition

A competition is consisted of participants, tasks and a goal: two or more participants solve the tasks individually or interactively and strive for the same goal. For a certain participant, the result of a competition is win or loss. Because in a competition one’s ability determine whether one can win or not, less-able students usually fail and eventually lose their interests. To change one’s relative ability and actual performance in a classroom is neither easy nor rapid. Because of the link between actual and perceived performance, the ranking of perceived performance is also hardly changed in a competition. EOT intends to solve the problem of unchangeableness with the capability of computers, so that every student could build confidence by equal opportunity of performing well with an altered perceived performance. Although “equality” is a political issue, computers are able to calculate students’ winning probabilities in a competition and try to balance their winning probabilities. The generalized procedure for EOT is an iterative process consisting of three main steps – estimating winning probability, manipulating learning tasks, and recording actual performance. To repeat the three steps may improve the validity of EOT.

Step 1: estimating winning probability. According to one’s previous actual performance, the system first calculates one’s winning probability in a condition that EOT is not involved. Under the condition without EOT, the students showing high actual performance are more able to complete the task and have higher probability of winning. Therefore, winning probability, a function of actual performance, can be regarded as not only the opportunity for success but also a synthetic estimate of one’s relative ability. Because the value of actual performance is unknown in the very beginning, the system initializes all values of students as zero, treating them as the same. After the first round, the system should have initial data for calculating the winning probability. According these values, the system will be able to sort the students in a hidden way.

Step 2: manipulating learning tasks. The system then adjusts the task so that the task difficulty can meet one's winning probability. In a competition, besides one's ability, the opponent's ability determines one's winning opportunity as well. Competing against a more-able opponent, for example, results in low perceived performance. Therefore, pairing each student with an opponent of similar ability provides a suitable difficulty and equal opportunity. Furthermore, the system starts from the most-able student and pairs students who are the most alike in the winning probability. In other words, every student has to compete against another student with similar ability. Under the tactic, less-able and more-able students may have almost equal opportunity of winning the game. If the student number is odd, there should be a remained student, the least-able student. The system allows the least-able student answering questions without any opponent. This is based on the assumption that giving the least-able student a better chance of winning; otherwise he may feel anxious.

Step 3: recording actual performance. The goal of this step is to obtain a dynamic and precise approximation of one's winning opportunity. When all students are doing the task in EOT condition, the system automatically records their most recent actual performance in the databases. Actual performance shows students' abilities to solve the task during the competition. According to the collected actual performance, EOT is able to estimating their winning probabilities in the step 1 of next competition.

When EOT is applied, every student receives a tailor-made task, of which the difficulty is appropriate to him/her, and thus has similar opportunities of performing well. "Opportunity" means that both success and failure are possible for all students regardless of their abilities. If perceived performance could really be separated from actual performance by EOT and unrelated to ability anymore, the ranking of perceived performance would not be constant as the relative ability. Instead, the ranking will become "fluid" in the classroom. That is, sometimes more-able students win and sometimes less-able students win. If all students could be situated in such a learning environment, they will believe their abilities are similar and they are willing to invest their efforts for improving themselves. In order to examine the effectiveness of EOT and its effects on students' beliefs, this study conducted an experiment.

3. Method

3.1. Research questions

EOT is a strategy to match the students who have similar ability in a competition, so that more-able and less-able students should have similar perceived performance. Accordingly, in order to examine the effectiveness, there were two research questions related to perceived performance. The first one was: *could EOT effectively balance the perceived performance without changing the mean of overall perceived performance in a competition?* Two strategies served as comparison conditions, matching randomly and matching a more-able student against a less-able student. The strategy to match randomly was designed to provide a baseline case with the factor of luck, whereas the strategy to match a more-able student against a less-able student was to provide another baseline case that likely happened in a competition. Furthermore, the second research question was: *could EOT effectively moderate the effect of ability on perceived performance in a competition?* If it could, the factor of ability would not influence students' perceived performance. All students could have similar perceived performance under EOT.

If the second research question is answered, it would lead to the third research question about beliefs in perceived performance: *could EOT further moderate the effect of ability on the expectation of perceived performance in a competition?* It was also hypothesized that EOT could also moderate the difference in the expectation of perceived performance, compared to the other two strategies. Finally, the last research question was about the effect of EOT on actual performance: *could EOT further improve actual performance in a competition?* That is, it was hypothesized that when students had similar expectation of perceived performance in EOT, all students regardless of ability should make more efforts and thus improve their actual performance more by EOT than in the other two strategies.

3.2. Subjects and material

The subjects were three third-year classes ($N_1 = 24$, $N_2 = 26$, and $N_3 = 30$). In this study, each question is a composite number (a positive integer having more than two factors); the corresponding answers are in the form of the multiplication of two factors. For instance, if the question is 14, then the correct answers are 2×7 , and 7×2 . For each question, the number of answers is dependent on how many factors

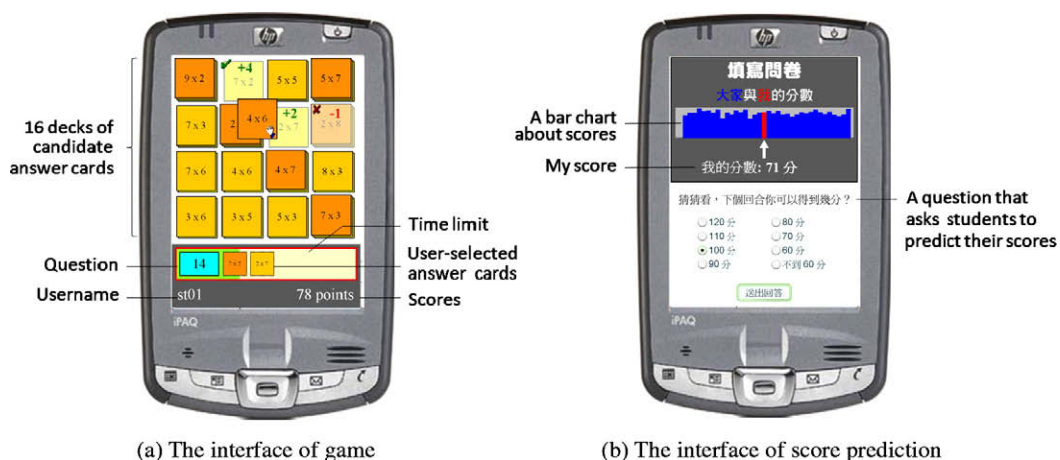


Fig. 1. AnswerMatching.

the composite number has. For third-year students, they have learnt the multiplication facts but did not have the concept of factors. Therefore, when seeing a question and its answers, they multiplied the numbers in the answers rather than factorizing the question.

3.3. Activity design

In this study, we adopted a revised version of a competition game, AnswerMatching (Fig. 1a), which was designed for practicing arithmetic on PDA after the calculation procedure has been taught (Chiang, 2006; Wu et al., 2007). The game required students to select the correct answers to ten questions as quickly as possible. Each question accompanied sixteen decks of candidate answer cards. After being shown a question, the students had to calculate mentally and then selected the answer cards from the sixteen decks in a shared working space.

Although each deck was comprised of cards having the same answer, each card in the same deck had different scores. Students were paired to compete with each other. If a student selected the first card in the correct deck within a given time, he received 4 points; yet if he selected the second correct card, he received 2 points only. However, if the student selected a wrong answer card, the score for that student was reduced by 1 penalty point. In a round, the students were required to find thirty answers. Thus, the range of total scores was from 0 to 120 points. A student received the highest score only if he selected all the first correct answer cards. Suppose a student was able to find all correct answers without mistakes. The relative calculation speed determined scores. For example, if a student who was slower than the opponent selected all the second correct answer cards, he received 60 points in total. In this experiment, there were few students getting scores fewer than 60 points because the subjects had the ability to solve the questions and they were all willing to calculate correctly in a competition. The system displayed their final scores at the end of every round; the student with the highest score was the winner of the round.

The competition was anonymous. That is, the students may find correct answers being taken away by their opponents but the system did not display the names of the opponents. However students may still guess the answers by following and repeating what the opponents have done. To prevent this, the system was designed to randomly take away wrong answers, forcing students to calculate.

AnswerMatching was designed to facilitate students' calculation ability, a.k.a. *procedural fluency* (Kilpatrick et al., 2001), defined as "skill in carrying out procedures flexibly, accurately, efficiently, and appropriately." According to the definition, the actual performance in AnswerMatching was defined as a triplet of *accuracy*, *efficiency*, and *trial number* to estimate procedural fluency. While accuracy was the percentage of correct answers, efficiency was the average number of correct answers in a given time and trial number was the number of answers which were found. With the definitions, the system could calculate the winning opportunity for every student by using formula (1). This formula was one's expected value of scores, which was a function of one's actual performance. In the formula, a , e , and n denoted one student's previous actual performance – accuracy, efficiency and trial number respectively; e_o denoted the average efficiency of all possible opponents. Furthermore, on the basis of the game rules, if the student got a correct answer, he/she had an approximate probability of $a \times \left(\frac{e}{e+e_o}\right)$ to take the first card and hence got 4 points and a probability of $a \times \left(\frac{e_o}{e+e_o}\right)$ to get 2 points; he/she also had a probability of $(1 - a)$ of losing 1 point for the wrong answers.

$$E_{Score}(a, e, n) = \left\{ a \left[4 \left(\frac{e}{e+e_o} \right) + 2 \left(\frac{e_o}{e+e_o} \right) \right] - (1 - a) \right\} \times n \quad (1)$$

For example, suppose the accuracy, efficiency, and trial number of a student were 80%, 15 correct answers per minute and 30 answers respectively; the average efficiency of his class was 10 correct answers per minute. His expected value of scores was 70.8 points. If another student had the same accuracy and trial number, but could find only 5 correct answer in a minute, his expected value of scores would be 58.0 points. Comparing the two expected values, the system could realize that the first student had higher ability and more winning probability than the second student.

3.4. Measures

In this study, the dependent variables were three kinds of performance which were measured – actual, perceived, and predicted performance. All data were automatically collected by the system.

Actual performance: was measured by accuracy, efficiency and trial number in the process of answering questions, according to the description in the last section. When students were playing the game, the system recorded the correctness of the answers, the time for finding correct answers, and the number of the found answers to calculate the actual performance for every student.

Perceived performance: was directly measured by game scores in the end of the rounds.

Predicted performance: was measured by one's prediction of perceived performance. That is, after each round of the game, students were asked to predict their game scores by a questionnaire item "how many points do you expect to get in next round" (Fig. 1b). Higher predictions implied higher expectancy for success and a more positive affective status.

3.5. Procedure

Prior to carrying out the experiment, the researchers conducted three rounds of AnswerMatching as an advance test for collecting the initial actual performance of multiplication calculation. In the advance test, although students had been informed that everyone would compete against an opponent, they actually played the game individually. However, none of the students noticed it because the system was designed to take away the wrong answers randomly. The collected actual performance was used in two ways: to examine the homogeneity of the three classes and to estimate every student's ability as described in the first step of EOT. A one-way ANOVA test showed that there were no differences in their accuracy ($F_{(2,77)} = 1.657$, $MSE = .014$, $p > .05$), efficiency ($F_{(2,77)} < 1$, $MSE = 7.748$, $p > .05$), and trial number ($F_{(2,77)} < 1$, $MSE = 61.594$, $p > .05$). The three classes were then assigned as EOT, RAN (random), and HTL (high-to-low) groups. In the group of EOT ($N = 24$), students with similar actual performance were paired. In RAN group ($N = 30$), students were paired randomly. In HTL group ($N = 26$), each more-able student was paired with a less-able student.

One week after the advance test, AnswerMatching was conducted again in the same classrooms. After a warm-up round, all students played six rounds (denoted by R1 to R6) within two sessions (80 min). In each round, students were required to answer ten questions. For each question, they were given 30 s to find two to four answers. Each round thus required about 5.5 min, and the students were given a 2-min break between every two rounds.

Although the questions were the same in all rounds, they were presented in different sequences, and the answer choices were also shown in different orders. Before the activity, all students were asked to review the rules. They were also told that they would be competing against an opponent. However, the identity of their opponent would not be disclosed, so as to prevent possible preconceptions about their opponents. During the experiment, one researcher led the activity; four researchers made observation and took field notes. All researchers are trained to help students if they encountered technical problems. After every round, the students were prompted to predict their scores in the following round. The students were also videotaped throughout the activity.

3.6. Data analysis

In order to investigate the distribution of perceived performance between the three groups, a 3×2 analysis of variance (ANOVA) on overall scores was adopted, with group (EOT, RAN, and HTL groups) and ability (more-able and less-able students, according to the actual performance in the advance test) as the between-subject variables. To test the effectiveness on perceived performance of students with different abilities, a 3×2 analysis of covariance (ANCOVA) was carried out, with group and ability as the between-subject variables, the average score in the first three rounds (R1 to R3) as the covariate, and the average score in the last three rounds (R4 to R6) as the dependent variable. ANCOVA was conducted to control for the potential effect of discrepancy in the initial perceived performance.

For exploring the relation between perceived and predicted performance, Pearson correlation coefficient was conducted. To test the effect on predicted and actual performance of students with different abilities, two-way ANCOVAs were carried out with the averages in the first three rounds as the covariate and the averages in the last three rounds as the dependent variable. Alpha was set at .05 for all statistical tests. All these analyses were done with the Statistical Package for the Social Science (SPSS Windows V. 13).

4. Results

Before the experiment, all the students appeared excited to be playing a computer game. Once the game started, they immediately became quietly engaged in finding answers. When students successfully selected all the answers before the time limit, they talked about how many points they had scored thus far. Furthermore, it was observed that they liked to compare their scores throughout the activity, showing their concerns about the perceived performance.

4.1. Effectiveness on perceived performance

Fig. 2 illustrates the overall scores in HTL, RAN and EOT groups. The two-way ANOVA indicated that there was a significant interaction between group and ability ($F_{(2,74)} = 5.483$, $MSE = 140.360$, $p = .006 < .05$, $partial \eta^2 = .129$, $observed power = .836$). However, it should be noted that the main effect of group was not significant ($F_{(2,74)} < 1$, $MSE = 140.360$, $p > .05$), showing that EOT did not significantly change the mean of overall scores compared to the other two groups (HTL: $M = 82.89$, $SD = 15.99$; RAN: $M = 83.11$, $SD = 12.34$; EOT: $M = 84.05$, $SD = 13.35$). Three independent sample t tests were then carried out for the three groups. For HTL and RAN group, the simple main effects of ability were both significant (HTL: $t_{(24)} = 4.869$, $SE = 4.53$, $p < .05$; RAN: $t_{(28)} = 3.502$, $SE = 3.82$, $p < .05$). For EOT group, the simple main effect of ability on score was not significant ($t_{(22)} = 0.002$, $SE = 5.57$, $p > .05$). The result showed that EOT balanced the perceived performance in a classroom without changing its mean because in EOT all students regardless of ability had opportunities to get the same scores.

Fig. 3 shows the tendency of perceived performance across time. A two-way ANCOVA showed that there was a significant interaction between group and ability ($F_{(2,68)} = 9.499$, $MSE = 108.049$, $p < .001$, $partial \eta^2 = .218$, $observed power = .976$). Three one-way ANCOVAs were then carried out for the three groups. For HTL group, the simple main effect of ability on the average score in the last three rounds was significant ($F_{(1,22)} = 39.328$, $MSE = 105.213$, $p < .001$, $partial \eta^2 = .641$). However, for RAN or EOT group, the simple main effect of ability

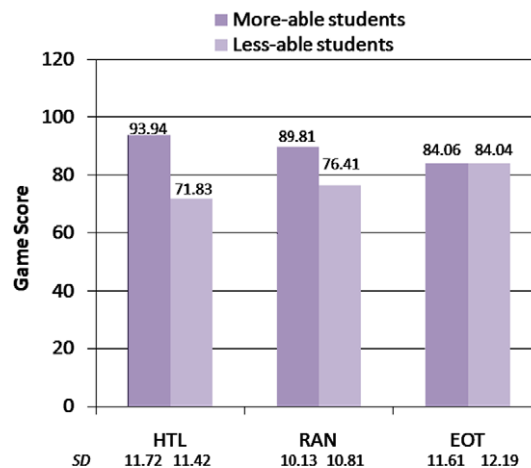


Fig. 2. The effect on the overall perceived performance.

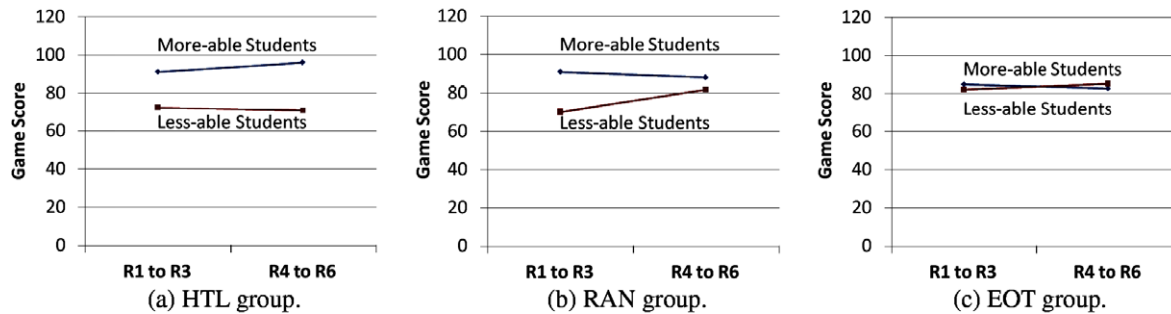


Fig. 3. Trends of perceived performance.

was not significant (RAN: $F_{(1,26)} = 2.862$, $MSE=97.906$, $p > .05$; EOT: $F_{(1,20)} < 1$, $MSE = 124.355$, $p > .05$). The result showed that when either EOT or RAN was adopted in the competition game, the perceived performance of students was not influenced by their abilities eventually.

Further analysis on HTL group showed that the score differences between more-able and less-able students were significant both in the first three rounds ($t_{(24)} = 4.272$, $SE = 4.442$, $p < .01$) and in the last three rounds ($t_{(24)} = 4.610$, $SE = 5.474$, $p < .01$). In RAN group, the score difference between more-able and less-able students was significant only in the first three rounds ($t_{(22,586)} = 3.575$, $SE = 5.783$, $p < .01$). For the group where EOT was applied, the score differences between more-able and less-able students were not significant in the first three rounds and the last three rounds. The results suggested that although RAN and EOT seemed to have the similar effect on the overall scores, only EOT had persistent effect in every round because of its optimal pairing algorithm. Interestingly, it was observed that many students in EOT group were aware their scores were close to each other's scores during the competition. For instance, when answering the fourth question in round 3, one of the students in EOT group happily told the researchers "I [have got] 34 points and he [has got] 32 points." At the same time the other one said "I [have got] 33 points." Compared with EOT group, the students in the other two groups did not show the phenomenon.

4.2. Effects on predicted performance

Fig. 4 illustrates Pearson correlation coefficients of scores and predictions in all rounds for the three groups. Most correlation coefficients were between 0.3 and 0.7, indicating that there were medium positive correlations in the experiment. Although the correlation coefficients of the three groups were similar in the beginning, the pattern seemed different in later rounds. In HTL group, the correlation coefficients went down from R2 to R4 and then rise in R5 and R6. The decrease implied that their prediction could not be largely attributed to their scores any more. The possible explanation would be that the students in HTL group predicted their scores based on the other factors, such as, their past perceived performance. The increase of correlation coefficients in the last two rounds showed that they were back to predict the scores based on current scores again. Interestingly, the trend of RAN was similar to that of HTL: a decrease from R2 to R5 and a final increase in R6, suggesting that the effect of RAN is close to the effect of HTL. But all of the correlation coefficients in RAN group were fewer than those in HTL, implying that in HTL group the student made prediction by the scores more than in RAN group. Compared to HTL and RAN group, the correlation coefficients of EOT group gradually declined from R3 to R6. The result showed that at the start the students in EOT group believed their future scores would resemble their current scores, but in later rounds the belief was weakened. Students started to make prediction based on the other factors more. However, these explanations still needed to be examined and investigated in the future experiment.

Fig. 5 shows the tendency of predicted performance across time. A 3×2 (group \times ability) ANCOVA, with the average prediction in the first three rounds as the covariate, indicated that the interaction between group and ability was significant ($F_{(2,68)} = 5.531$, $MSE = 198.670$, $p = .006$, $partial \eta^2 = .140$, $observed \ power = .838$). For HTL group, the simple main effect of ability on predicted scores was significant ($F_{(1,22)} = 26.397$, $MSE = 161.960$, $p < .001$, $partial \eta^2 = .545$). Similarly, for RAN group, the effect was also significant ($F_{(1,26)} = 7.081$, $MSE = 260.201$, $p = .013$, $partial \eta^2 = .214$). However, for EOT group the simple main effect of ability on predicted scores was not significant. These findings showed that when EOT was applied in the competition game, students' confidence was not influenced by their abilities. Although RAN and EOT had similar effect on the overall scores, EOT had better effect on predicted performance than RAN. The reason perhaps was that by using the random strategy a less-able student still had more chances to be paired with an opponent who had higher ability.

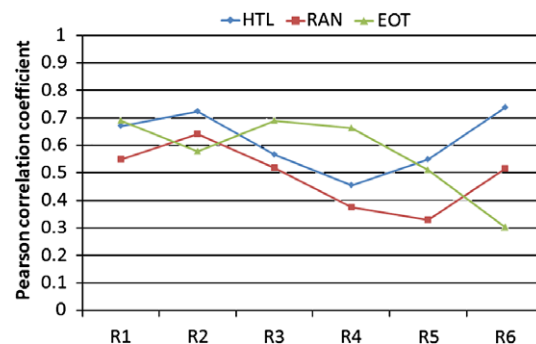


Fig. 4. Pearson correlation coefficient between perceived and predicted performance.

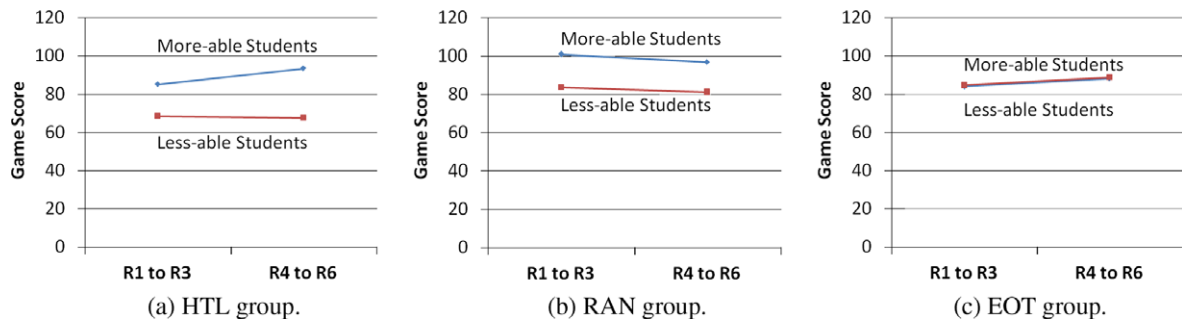


Fig. 5. Trends of predicted performance.

Pairwise comparison indicated that in HTL group the differences of predicted scores were significant both in the first three rounds ($t_{(15.421)} = 2.641, SE = 6.210, p < .05$) and in the last three rounds ($t_{(24)} = 4.032, SE = 6.361, p < .001$). In RAN group, the differences were also significant in the first three rounds ($t_{(28)} = 2.250, SE = 7.655, p < .05$) and in the last three rounds ($t_{(28)} = 2.538, SE = 6.175, p < .05$). The result suggested that even using the random strategy could not moderate the difference of confidence between more-able and less-able students. However, in EOT group, the differences of predicted scores in the first three rounds and the last three rounds were not significant, suggesting that EOT could also have persistent effect on confidence in a similar way to perceived performance.

4.3. Effects on actual performance

Table 1 shows the results about accuracy, efficiency and trial number, that is, actual performance. Two-way ANCOVAs with the values in the first three rounds as the covariates indicated that the interactions between group and ability were not significant on accuracy ($F_{(2, 68)} < 1, MSE = .004, p > .05$), efficiency ($F_{(2, 68)} < 1, MSE = 5.388, p > .05$) and trial number ($F_{(2, 68)} < 1, MSE = 20.801, p > .05$), suggesting that EOT did not change students' procedural fluency compared with HTL and RAN strategies even though their expectancies for success were changed. Furthermore, the main effect of ability were significant on efficiency ($F_{(1, 68)} = 32.273, MSE = 5.388, p < .001$) but not significant on accuracy ($F_{(1, 68)} = 2.243, MSE = .004, p > .05$) and trial number ($F_{(1, 68)} < 1, MSE = 20.801, p > .05$). The results showed that the main difference of subjects' actual performance was how fast they could get a correct answer, rather than how able they were or how many answers they could find.

4.4. Summary

The findings about game scores answered the two research questions regarding perceived performance: EOT could balance the perceived performance and moderate the effect of ability on perceived performance. Furthermore, because students in EOT condition were aware of similar perceived performance, EOT could further moderated the effect of ability on predicted performance, answering the third research question. However, the findings about actual performance did not answer the last research questions. That is, students in EOT group did not significantly improve their actual performance.

Although in this experiment RAN had a similar result to EOT, which moderated the effect of ability on perceived performance, RAN could not effectively moderate the effect on predicted performance. Actually, the result of RAN is close to that of HTL because it is not an optimal strategy: less-able students still had high opportunity to compete with more-able students. In both RAN and HTL groups, less-able students still received low perceived performance and had low expectation of future perceived performance.

5. Discussion

5.1. Actual and perceived performance

The finding did not show that EOT could improve actual performance in a competition. In other words, there was no practice effect in the experiment, that is, the actual performance of students was stable. There are two possible reasons. The first one is ceiling effect,

Table 1
The results of actual performance.

DV's	HTL group				RAN group				EOT group				
	More-able students		Less-able students		More-able students		Less-able students		More-able students		Less-able students		
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	
Accuracy	R1-3	.93	.07	.88	.10	.94	.05	.86	.13	.95	.02	.95	.04
	R4-6	.94	.05	.90	.08	.96	.06	.93	.04	.95	.09	.95	.03
Efficiency	R1-3	13.63	2.84	11.33	2.40	14.40	2.40	11.23	2.35	13.40	3.84	10.23	1.08
	R4-6	15.15	4.03	12.02	3.29	17.14	2.60	14.96	2.66	15.07	4.85	11.37	1.37
Trial number	R1-3	31.31	5.48	32.33	5.49	31.08	3.12	31.33	5.69	30.14	1.84	28.39	2.40
	R4-6	31.23	2.96	31.97	5.21	32.04	6.07	30.41	2.23	29.36	7.09	29.75	1.97

The range of accuracy is from 0 to 1.
The unit of efficiency is the number of correct answers per minute.
The unit of trial number is the number of answers in total.

implying that the students have already reached the upper bound of actual performance. Another reason was possibly the time limit of the experiment. If future studies could conduct a long-term experiment and increase the difficulty of questions, the students would likely improve their ability eventually. Although the result was not satisfying, it brought two benefits to explaining the effects of EOT. First, the stability helped the experiment decrease the variances. Therefore, the main effect of ability could be attributed to the previous competence of the students. Second, the result also showed that EOT could separate perceived performance from actual performance. Even if the effect on actual performance was not significant, EOT could effectively change perceived performance in the experiment.

Although the results indicated that both EOT and RAN could moderate the effect of ability on perceived performance, the effectiveness of RAN is neither instantaneous nor guaranteed. In the first three rounds of RAN, the difference between two groups was significant; in the last three rounds, RAN could finally decrease the main effect of ability on perceived performance. However, RAN could not balance the perceived performance, suggesting that chances are not guaranteed to moderate the effect of ability on perceived performance. Only in EOT condition could less-able students have similar opportunity of performing well to more-able students. It should be noted that the results did not imply that the perceived performance of EOT group was constant all the time. In fact, students in EOT group sometimes got higher scores and sometimes lower regardless of their abilities. They thus had similar average scores.

5.2. Perceived and predicted performance

In the experiment, there was a positive and medium correlation between perceived and predicted performance. The result agrees with the expectancy-value model, in which expectancy influences performance while performance also influences future expectancy. Furthermore, because EOT balanced the perceived performance in the experiment, all students could anticipate receiving similar scores regardless of ability. Even if their scores were not exactly the same, the differences were small. Such advantage of EOT provided students with information for developing confidence. It is also observed that the students' feelings and attitudes toward the future were indeed affected by their perceived performance. In HTL and RAN groups, students appeared to perceive the score differences during the competition. The more-able students often talked about their scores excitedly and loudly, while the less-able students were worried that they could not catch up. The results agree with our assumption that in an environment with unequal opportunity of performing well, the less-able students have lower confidence in themselves than the more-able students. In EOT group, students took the other's scores as temporary goals because their scores were close to each other in answering the questions.

Therefore, EOT moderated not only the difference in perceived performance, but also the difference in predicted performance. The students in EOT group could have similar future expectancy regardless ability. However, some researchers might question that EOT were proscribing the rights of those more-able students because they might feel that they should receive better scores than the others, but in this study they got similar scores. There are two possible answers. First, it is argued that in an unequal environment where more-able students take an advantage position they will eventually find the learning tasks too easy and unchallenging. For more-able students, challenges may facilitate their motivation for learning and keep them engaged in the tasks. Second, if the so-called "more-able students" could be really situated in an equal environment, where every learning task was equipped with EOT, for a long time, the label "more-able students" or "less-able students" would disappear. Students will not think of themselves as "more-able" or "less-able students." Instead, all of them will regard themselves as "good performers" because they know they are able to do it. This also suggests to redesign the classroom completely and to conduct longitudinal experiments in the future.

5.3. Implications

In a conventional classroom, lecture-based instruction and summative assessment practices still predominate. Students, in their everyday school life, still encounter endless exercises and examinations that are supposed to help teachers effectively identify those who have not yet acquired the desired knowledge or skill. These learning activities are designed to use the same criteria to judge the achievement of all the students. However, students are unique individuals. Even in the same classroom, there are students with different abilities, making progress at their own pace. It is impossible and unequal that identical learning tasks will be suited to the development and abilities of all students. EOT has the potential to create an equal learning environment by manipulating learning tasks in a way of hiding information.

Some may think that holding the information via EOT from the students is not appropriate. Thus, the issue – *is EOT a form of cheating?* – could be an open issue. If it is a form of cheating, it should be considered as a white lie because it is for the sake of protecting their confidence in learning. Actually, the strategy to hide information about actual performance has been used in schools: teachers do not show students the ranking of tests for avoiding serious comparison. Actual performance should be a kind of private information and should be revealed to the information owners and the teacher.

Even though there was no evidence that the confidence built in games or competitions would influence the ability perception in learning, the study was still a good case to investigate how a typical competition influenced students' beliefs in ability and how EOT to change it. The more-able students in HTL or RAN group received substantially higher scores than their opponents. They, moreover, were excited about their perceived performance, which shook the confidence of the other students. Conversely, the score differences in EOT group were fewer than those in HTL and RAN groups, suggesting that EOT provided similar opportunities of success for all students. Hence, if designed carefully, EOT could provide every student with a sense of achievement and satisfaction, even in a competitive environment.

Although EOT was implemented by assigning comparable opponents in order to adjust the task difficulty in this study, it was not the only algorithm for equalizing the opportunity of performing well in a competition. Remember that a competition comprises participants, a task and a goal. Thus, another possible way is to assign each student a suitable task according to his ability, for example, in this case, a set of appropriate questions. Accordingly, more-able students can solve new, harder and more complex problems while the less-able students can continue practicing familiar questions at the same time. Nevertheless, in a simple competitive environment like AnswerMatching, students may become aware that they are being tested differently, which may disobey the principle of hiding information. One of the big challenges is to redesign learning activities with really equal opportunity, which needs more design in detail. It is expected that the findings will encourage researchers and educators to design and experiment with more advanced EOT models.

The study also gives some implications as to the potential of computers to create an equal learning environment other than competition. This is not to say to equalize their perceived performance. If the perceived performance is equal every time, the sense of achievement and

satisfaction is taken away, too. Rather, in an equal environment, successes and failures are interwoven, giving a reasonable hope that success is possible if the student is willing to invest his effort. For less-able students, even a small success can provide a sense of achievement and positive learning experience. In a learning environment with equal opportunity, they could feel contented during their school life and would not think of themselves as hopeless losers. For more-able students, who are used to continuous success, occasional failures can draw their attention, and keep them focusing on the learning task rather than repeating what the teacher has taught without thinking. As Rohrkemper and Corno (1988, p. 303) noted, “Meaningful learning has much to do with false starts, thwarted tries, and frustrated attempts.” A failure, although annoying, can also provide an opportunity for reflection and self improvement. Therefore, an equal learning environment should be consisted of both successes and acceptable failures. If every student, regardless of ability, could really learn in such an environment, their confidence could be built and they would not find any difference in ability among them.

5.4. Research limitations

Several limitations in the study should be addressed. First, because of the financial constraint, it is not possible to have more computers and also the subjects in this study. Second, the study lacked a longitudinal experiment not only to investigate the improvement of actual performance but also to explore potentially positive and negative effects in an equal learning environment. Third, the validity of the estimation formula for approximating ability still needs to be proved. Fourth, we have not explored other psychological constructs besides expectancy for success, such as self-efficacy, perceived ability, and so forth. At last, the study also needs to apply EOT in the other scenarios besides competition. It is expected that EOT is also useful to redesign other activities for building an equal opportunity environment.

6. Conclusion

The study proposes the EOT, an approach to moderating differences in perceived performance between more-able and less-able students by matching every student with an opponent with similar ability. The results of the experiment indicated that EOT could decrease the main effect of ability on perceived performance, so that students could have similar opportunity of achievement regardless of ability. The experiment also revealed that EOT could further decrease the main effect of ability on predicted performance. In other words, when EOT is applied in a competition, less-able students have similar ability belief to more-able students. Under the tactic, all students are confident of accomplishing their learning goals. If students can be situated in such an environment for a long time, they would likely begin to value their own abilities owing to the similar expectation of high perceived performance. Furthermore, the experience of success builds confidence and pushes students to invest more efforts in subsequent attempts with minimal anxiety and boredom.

AnswerMatching, the activity used in this study, is a typical social environment with intense competition. By manipulating the task difficulty, EOT creates an equal learning environment in which learners are given appropriate challenges whereby they can build confidence. As the same way that people in society pursue wealth and position, students pursue high perceived performance in classrooms. However, the education machine asks students to meet the curricular requirements without taking care of their unique affective statuses. The phenomenon of individual difference actually reflects the imperfection of the current education system. An identical learning process for everyone is actually a social inequality and ignores students’ rights to pursue joyful learning. It is our responsibility to provide a fair learning environment where every student can develop the ability and build the confidence in order to face real and unfair situations in their future life.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financial support (NSC 97-2520-S-008-001). The authors would also thank the assistance of the teacher in Shan-Da elementary school in Taoyuan County, Taiwan.

References

- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Psychological Review*, 84, 191–215.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. NY: Freeman.
- Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children’s aspirations and career trajectories. *Child Development*, 72, 187–206.
- Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goals effects revisited. *Journal of Applied Psychology*, 88, 87–99.
- Brusilovsky, P. (1999). Adaptive and intelligent technologies for web-based education. *Künstliche Intelligenz*, 4, 19–25.
- Brusilovsky, P., & Peylo, C. (2003). Adaptive and intelligent web-based educational systems. *International Journal of Artificial Intelligence in Education*, 13, 159–172.
- Chiang, M. C. (2006). AnswerMatching: A small group competitive digital game for practicing arithmetic with asymmetrical competition strategy. Master Thesis, National Central University, Jhongli, Taiwan. (Text in Chinese)
- Cheng, H. N. H., Deng, Y. C., Chang, S. B., & Chan, T. W. (2007). EduBingo: Design of multi-level challenges of a digital classroom game. In T. W. Chan, A. Paiva, & D. W. Shaffer (Eds.), *The first IEEE international workshop on digital game and intelligent toy enhanced learning* (pp. 11–18). Los Alamitos, CA: IEEE Computer Society.
- Collins, J. (1982). *Self-efficacy and belief in achievement behavior*. New York: American Educational Research Association.
- Crockenberg, S., & Bryant, B. (1978). Socialization: The “implicit curriculum” of learning environments. *Journal of Research and Development in Education*, 12, 69–78.
- Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.
- Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.
- Eccles, J. S. (1987). Gender roles and women’s achievement-related decisions. *Psychology of Women Quarterly*, 11, 135–172.
- Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., et al. (1983). Expectancies, values, and academic behavior. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco: W.H. Freeman.
- Eccles, J. S., Adler, T. F., & Meece, J. L. (1984). Sex differences in achievement: A test of alternate theories. *Journal of Personality and Social Psychology*, 46, 26–43.
- Eccles, J. S., & Wigfield, A. (1995). In the mind of the achiever: The structure of adolescents’ academic achievement related-beliefs and self-perceptions. *Personality and Social Psychology Bulletin*, 21, 215–225.
- Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, 53, 109–132.
- Eccles, J. S., Wigfield, A., Harold, R., & Blumenfeld, P. B. (1993). Age and gender differences in children’s self- and task perceptions during elementary school. *Child Development*, 64, 830–847.
- Greene, B. A., & Miller, R. B. (1996). Influences on achievement: Goals perceived ability, and cognitive engagement. *Contemporary Educational Psychology*, 21, 181–192.
- Gilbert, D. T., Giesler, R. B., & Morris, K. A. (1995). When comparisons arise. *Journal of Personality and Social Psychology*, 69, 227–236.

- Hechinger, G., & Hechinger, F. M. (1974). Remember when they gave A's and D's? *New York Times Magazine*, pp. 84, 86, 82.
- Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academies Press.
- Kohn, A. (1992). *No contest: The case against competition*. NY: Houghton Mifflin.
- Levine, J. M. (1983). Social comparison and education. In J. M. Levine & M. C. Wang (Eds.), *Teacher and student perceptions: Implications for learning* (pp. 29–55). New York: Erlbaum.
- Marsh, H. W., & Craven, R. (1997). Academic self-concept: Beyond the dustbowl. In G. D. Phye (Ed.), *Handbook of classroom assessment: Learning, adjustment, and achievement* (pp. 131–198). San Diego, CA: Academic Press.
- Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment and performance in mathematics. *Journal of Educational Psychology*, 82, 60–70.
- Melis, E., Andrès, E., Büdenbender, J., Frishauf, A., Gogvadse, G., Libbrecht, P., et al. (2001). Active math: A web-based learning environment. *International Journal of Artificial Intelligence in Education*, 12(4), 385–407.
- Mitrovic, A. (2003). An intelligent SQL tutor on the web. *International Journal of Artificial Intelligence in Education*, 13(2–4), 171–195.
- Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review*, 110, 472–489.
- Nakabayashi, K., Maruyama, M., Koike, Y., Fukuhara, Y., & Nakamura, Y. (1996). An intelligent tutoring system on the WWW supporting interactive simulation environments with a multimedia viewer control mechanism. In H. Maurer (Ed.), *Proceedings of WebNet'96, world conference of the web Society* (pp. 366–371). Charlottesville, VA: Association for the Advancement of Computing in Education.
- Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66(4), 543–578.
- Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. *Contemporary Educational Psychology*, 26, 426–443.
- Rohrkemper, M., & Corno, L. (1988). Success and failure on classroom tasks: Adaptive learning and classroom teaching. *The Elementary School Journal*, 88(3), 269–312.
- Stapel, D. A., & Koomen, W. (2005). Competition, cooperation, and the effects of others on me. *Journal of Personality and Social Psychology*, 88, 1029–1038.
- Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, 25, 68–81.
- Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbretton, A., Freedman-Doan, K., et al. (1997). Changes in children's competence beliefs and subjective task values across the elementary school years: A three-year study. *Journal of Educational Psychology*, 89, 451–469.
- Wu, W. M. C., Cheng, H. N. H., Chiang, M. C., Deng, Y. C., Chou, C. Y., Tsai, C. C., et al. (2007). Answermatching: A competitive learning game with uneven chance tactic. In T. W. Chan, A. Paiva, & D. W. Shaffer (Eds.), *The first IEEE international workshop on digital game and intelligent toy enhanced learning* (pp. 89–96). Los Alamitos, CA: IEEE Computer Society.
- Yu, F. Y. (2003). The mediating effects of anonymity and proximity in an online synchronized competitive learning environment. *Journal of Educational Computing Research*, 29(2), 153–167.
- Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, 25, 82–91.