

# An International Educational Collaboration Across Cultures, Languages, and the Pacific Ocean

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**Abstract:** Promoting a student's ability to think critically, and effectively solve multi-disciplinary problems is viewed as an international educational priority. Fully aware of the importance of such a need across broad societal domains, the Chinese educational community is at the forefront of reforming its teaching pedagogies and adopting innovative assessment systems. In response, an international collaboration has been established between the IMMEX Project at UCLA, the Placentia Yorba Linda Unified School District and the Chancheng School District of Foshan, in the Guangdong Province, China whose goals are to foster the development of problem solving skills among Chinese students and to begin a cross cultural educational exchange. We report on a pilot project utilizing IMMEX problem solving software that began in 2007.

## Introduction

One World, One Dream (1). The theme of the 2008 Beijing Summer Olympics is a fitting backdrop for the international partnership established by the investigators of this paper.

The IMMEX (Interactive Multi-Media Exercises) Project was initiated in 1989 as a way to improve the diagnostic skills of medical students by having them perform computer diagnostic simulations (Stevens, McCoy, & Kwak, 1991). It became apparent that it was important to engage students in problem solving activities long before they reached medical school, and an extensive program of community outreach was started (Palacio-Cayetano et al, 1999). This program has grown into an online library of simulations that serve audiences from elementary school to medical school. In addition to providing students with opportunities to engage in scientific problem solving, IMMEX also provides detailed assessments of students' problem-solving skills and learning trajectories (Stevens et al., 2004, 2005, 2006), allowing comparisons among students, classes and schools. With universal online access it has become possible to extend IMMEX technologies to international audiences to establish frameworks for comparisons of problem solving approaches across countries. While the TIMSS study has provided a measure of science and math literacy and skills across countries, the format of the test did not lend itself to detailed assessment of complex problem solving skills.

In 2006 collaboration was established between the IMMEX Project and the Chancheng Education Bureau in Guangdong Province, China. The goal of this partnership is to initiate studies to directly compare the strategies used by students in the USA and China to solve complex middle school science problems. In addition to technology-related challenges, these activities posed the uncertainties of culture, language, and communication time/distance. Most importantly, these efforts have to be practical and show rapid short-term, but significant accomplishments in order to be sustainable by all partners. In this manuscript we describe preliminary positive results from a 6 month pilot project involving five middle schools and 135 students.

## Methods:

The IMMEX system presents case-study-type problems which students solve by searching a variety of data and information sources. The IMMEX activities focus on problem solving as a means of enriching science and math content learning – as opposed to content learning divorced from scientific process or scientific process that is not adequately integrated with content learning. IMMEX problem sets are aligned with the California standards in science and math for Content and Investigation and Experimentation strands and the exercises are conducted as part of normal classroom activities. A sample task is called *Paul's Pepperoni Pizza*, which provides introductory level exercises (Figure 1).

To solve this problem students must navigate through the relevant content in the menu items in order to uncover the variables. Once discovered, basic math skills are adequate to arrive at a correct solution. Students

are given two chances to answer the problem correctly. Once they solve the problem or exhaust the number of attempts, they are directed to a new case. Cases are delivered in random order.

<p><b>PROLOGUE</b></p> <p><b>It is Saturday afternoon and the Stingers Baseball team heads out to Paul's Pepperoni Pizza Palace for lunch. The team sits down for lunch. Determine how many pizzas they ordered.</b></p> 	<p><a href="#">Menu</a></p> <p><a href="#">Team Stats</a></p> <p><a href="#">Servings</a></p> <p><a href="#">Slices per person</a></p> <p><a href="#">Drinks per person</a></p> <p><a href="#">Number of Drinks Ordered</a></p> <p><a href="#">Interviews</a></p> <p><a href="#">Helpful Hints</a></p>	<p>Servings&gt;Slices per Person</p> <h2>Slices per Person</h2> <p>Each person had 2 slices.</p> 
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Figure 1. Paul's Pepperoni Pizza Problem-set. Prologue and menu items.

In addition to providing students with opportunities to engage in scientific problem solving, IMMEX supports detailed assessments of students' problem-solving skills and learning trajectories (Stevens et al., 2004, 2005, 2006). Although there are dozens of ways to approach and solve IMMEX problems, the cases are closed-ended or well-defined in that a problem is either solved or not solved. Each IMMEX "problem set" contains 6-50 "cases" of the problem with the same interface and resources, but with different unknowns and supporting data (Stevens & Palacio-Cayetano, 2003). For instance, there are 9 versions of the *Paul's Pepperoni Pizza* exercise, each with a unique solution. The opening scenario, or prologue, remains the same, but the content in the menu items varies from case to case. IMMEX includes a layered system of analytic tools to dynamically model various aspects of students' problem solving performance, including: 1) The strategic sophistication of a student at a particular point in time (a performance measure), 2) How the student arrived at this level (a progress measure), 3) How s/he will likely progress with more practice/experience (a predictive measure), 4) Whether this strategic level will be maintained (a stabilization measure), 5) What instructional interventions could most effectively accelerate each student's learning?

### Timeline of Activities:

Beginning in December 2006, through the direct efforts of our IMMEX China liaison and Chinese colleagues, the IMMEX system has been introduced to multiple school districts in the city of Foshan. The administrators at Chancheng School District embraced the IMMEX teaching pedagogy and technology enthusiastically, and decided to participate in piloting the IMMEX system as a part of its ongoing educational reform act.

In March 2007, Dr. Ron Stevens, director of IMMEX project at UCLA paid a personal visit to Chancheng School District to meet the administrators, teachers and students; and evaluate the technical challenges of conducting such a pilot project. This joint exchange of ideas, and the enthusiasm of Chancheng's education community towards modern technology and innovative education methods facilitated the rapid establishment of a joint memorandum of understanding to proceed with the pilot test before summer 2007.

The six-member IMMEX team traveled to Foshan and provided logistics, technical support, teacher instruction, cultural guidance and overall project facilitation. The Chinese counterparts, under the direction of Professor Renyue Xiao, made local arrangements with teachers, principals, district supervisors, and municipal officials allowing the workshop to begin on schedule and without difficulty.

The workshop was three days long but was supported by preliminary activities. For instance, the IMMEX team visited the site, met with administrative and technical staff and made logistical decisions on room use, handouts, and use of the existing technology. IMMEX came with a workshop schedule and documents and modified them as needed during the day and then each evening made changes for the following day. The need for flexibility was important because this was the first time the IMMEX team had presented the material in a foreign language in a setting with potentially different cultural and teaching norms.

On day one the workshop was introduced by the Director of the Chancheng School District. Then a case was made for problem solving as an important life skill that can be addressed in a school setting. This was

followed by an introduction to using IMMEX in the classroom. IMMEX staff modeled the teacher performance and the attending teachers modeled the student response. Participants first worked on a case of *Paul's Pepperoni Pizza* together. Then the teachers tried to solve individual cases on their own, exploring alternate pathways for solving. After solving several cases of *Paul's Pepperoni Pizza*, teachers explored other problem sets.

On day two the process was repeated with another problem set, again modeling a teaching strategy that emphasized exploring the problem space first before choosing an answer. The teachers then resumed exploration of the problem sets. During this time two students from the school site came in and solved *Paul's Pepperoni Pizza* and another more challenging problem set (Figure 2). This lay to rest concerns that the students would have difficulty solving the problem in English with minimal coaching. After lunch another 12 students (8 elementary school and 4 middle school) joined the teachers. The students solved *Paul's Pepperoni Pizza* and other problem sets while the teachers closely observed and interacted with the students to differing degrees, in much the same format as would be the case in the USA. The teachers were pleased to see that the students could problem solve in English using IMMEX. As a result the teachers were less concerned about their students' ability to solve IMMEX problems.



Figure 2. Middle School students perform English language exercises in Foshan, China.

The last activity of day two involved one of the workshop teachers taking the role of a student using a high school problem set, *Hazmat*. The workshop teacher spoke English but did not have an extensive background in chemistry, the subject area of *Hazmat*. As a result, partway into the problem he reached an impasse. At this point, in front of his fellow teachers he took the role of student and the lead IMMEX teacher took the role of classroom teacher. The participating teacher modeled the need to explore the problem space, to take risks, and to make educated guesses in the problem solving process. He explained to his fellow teachers how he was approaching problem solving in terms of his own teaching milieu. Together the two teachers were able to model and explain the coaching aspect that a teacher engages in when using IMMEX in the classroom while bridging both a language barrier and cultural gap.

On day three participating teachers completed a level I certification process and wrote an implementation plan. There was a final discussion on classroom coaching strategies and expected student behaviors. Those who passed the exam obtained Beginning Level Certification.

## **Implementation**

Following the workshop, five schools requested experimental summer classes for their students. To meet this request the IMMEX team sought out an expert advisory group, drawing on the personnel who had helped organize the workshop, to provide technical support during and after these experimental classes. The trainees in these summer classes included students from the 4<sup>th</sup>, 5<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> grades, divided into five classes. Each class consists of students from the same grade but with some students having excellent academic achievement scores (top 15%), some with average academic achievement scores and some with lower academic achievement scores. This will allow future comparisons by academic rank. Similar data is available for classrooms in the US as reported elsewhere (Stevens & Thadani, 2007).

The next phase of teacher training for the Chancheng district started in October of 2007. The target audience were the teachers who had conducted classes during the summer. The workshop focused on student data reports and was conducted live remotely using online conferencing software from two sites in California, one in the IMMEX headquarters and the other from the Educational Services Center of the Placentia Yorba

Linda Unified School District. User access to data reports were first introduced so the teachers would be able to utilize these tools in real-time for future classes. The data collected was discussed in detail, strategies for using data reports in classrooms for enhancing problem solving were presented and teacher questions were answered. Similar to the first workshop, this session was conducted in English and translated into Chinese. Those who passed a certification test obtained Intermediate Level Certification.

The data from the experimental summer workshop classes was collected, analyzed, and reports were prepared for the Chancheng School District as well as for each of the five schools that conducted classes. Each report details the gender and grade level of the students in the classes, their academic achievement ranking, problem sets used, and number of performances collected. The performances are categorized into different levels of efficiency and effectiveness as well as compared to their academic achievement ranking. Sample strategies were also presented and discussed in the reports. As a result of these reports and their recommendations, further research, and additional professional development conferences using the Internet are planned with teams of teachers, administrators, and researchers.

## Results

Table 1. Data collected from Chancheng School District (November '07)

Schools	5	Classes	5
Certified Teachers	15	Students	135
Grade Levels	4, 5, 7, 8	Female	53
		Male	82
Problem Sets	5	Performances Analyzed	2,322
Cases	40	Solve Rate	53.73%

There were 2,322 performances collected in China from five different problem sets. In this paper we report on the data only from *Paul's Pepperoni Pizza* as this was performed by all students.

For the pilot study we focused on reporting to the schools the initial two layers of the IMMEX assessment system and provided online reports in real time of the number of problems a student solved as well as Strategic Performance Maps (SPM) of how the problem was solved (Figure 3).

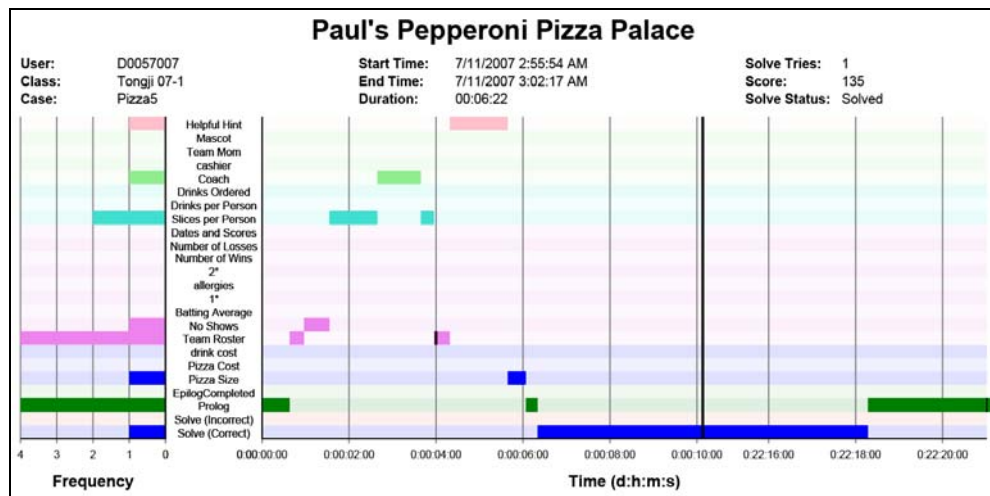


Figure 3. Strategy Performance Maps show the duration of the exercise, and solve status (top). The sequence, duration, and frequency of items viewed are displayed in the timeline (opaque bars). The menu items (column) are categorized by alternating transparent rows.

As students solve a series of cases, they initially began by exploring the problem space and with practice, their approaches become more focused and refined. This typical progression for one student is shown in Figure 4. By the third performance the student has already stabilized with a preferred approach (Pizza size, Slices per Person, Team Roster and No Shows). As is typical for many of the better students, after this student developed a successful approach s/he attempted to make the approach leaner by reducing some of the tests ordered and ended up missing the problem. Then he went back to the successful strategy.

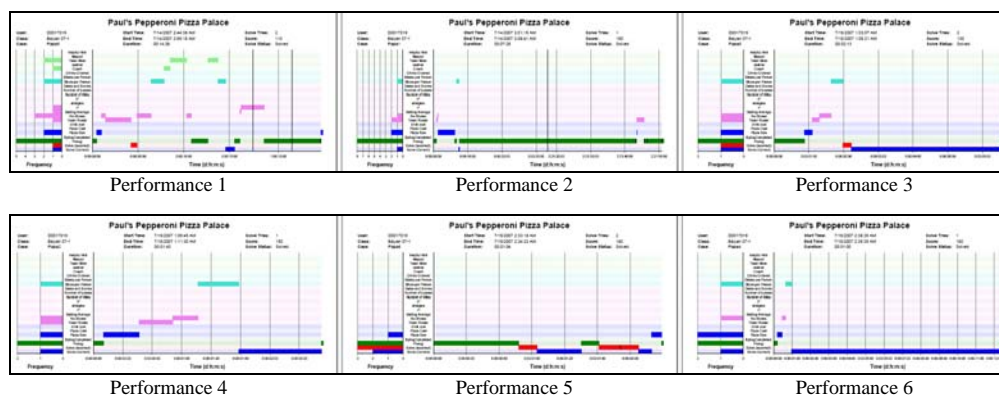


Figure 4. Sequence of Strategy Path Maps – typical student.

A second set of performances represents struggling students (Figure 5). After an extensive exploration of the problem space on the first performance, this student resorted to extensive guessing.

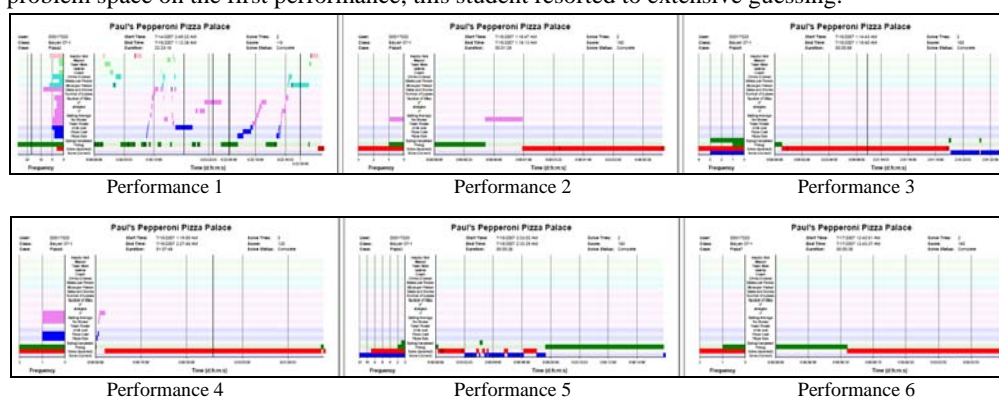


Figure 5. Sequence of Strategy Path Maps – a struggling student.

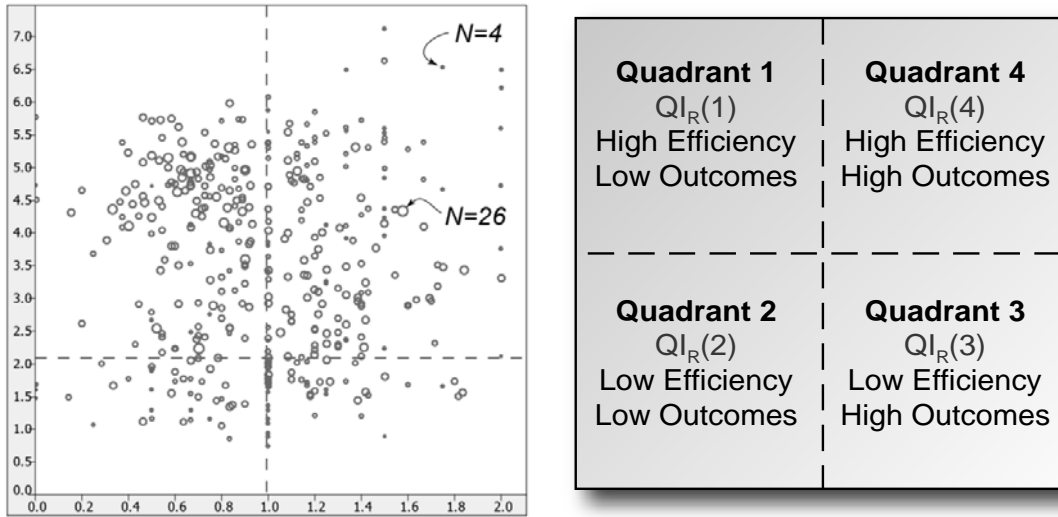
### Future Extensions

While the SPMs have immediate utility for providing formative feedback to students, for eventual comparisons across schools and countries, a simpler reporting metric would be useful. The approach we have used is to consider students' choices about each step in an IMMEX problem in terms of resources (what information can be gained) and costs of obtaining the information (Haider & Frensch, 1996; Stevens & Casillas, 2006). Students who review all available resources are not being very efficient, although they might eventually find enough information to arrive at the right answer. Other students might not look at enough resources to find the information necessary to solve the problem, i.e., they are being efficient but at the cost of being ineffective. Students demonstrating high strategic efficiency should make the most effective problem-solving decisions using the fewest number of the resources available. In contrast, students with lower efficiency levels will require more resources to achieve similar outcomes and / or will fail to reach acceptable outcomes. As students gain experience solving problems in different science domains, this should be reflected as a process of resource reduction.

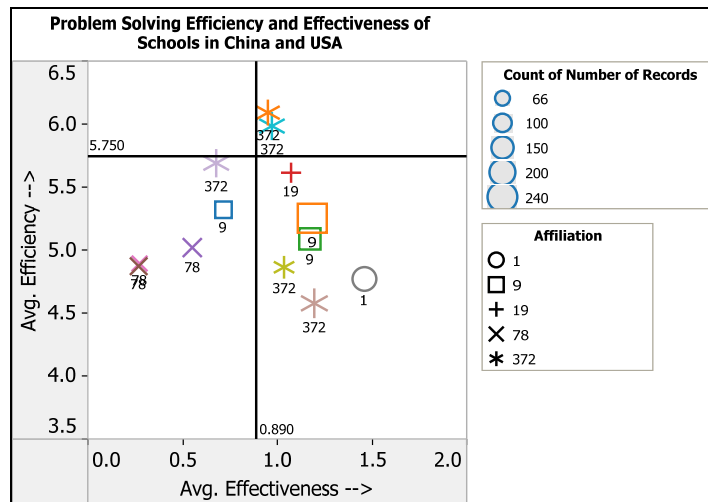
By analyzing students' problem solving behavior in terms of effectiveness and efficiency, we can derive and validate a generalized metric of problem solving that would be applicable across domains and classrooms, and used to monitor progress throughout the year. The core components of strategic efficiency are 1) the quantity of resources used vs. the quantity available, 2) the value of the resulting outcomes expressed as a proportion of the maximum outcomes, and 3) the quality of the data obtained. The resulting index is termed the Strategic Efficiency Index (SEI) and is described in detail elsewhere (Stevens, 2007). When the SEI for a series of performances are plotted against the average solve rate, a distribution similar to that shown in Figure 6 is obtained.

The distribution of problem solving performances around the means of the SEI and average solve rate define quadrants of student performances as shown in Figure 6. As described previously (Stevens & Thadani, 2007, Stevens, 2007), the students in quadrant 1 (upper left corner) mostly represent guessing and were assigned

a value of '1'. Students in the lower left (or quadrant 2) ordered many tests, but failed to solve the problem and were assigned a '2'. The lower right (quadrant 3) represents students ordering many test but solving the problem and were assigned '3'. Finally, the most efficient students, using few resources and solving correctly, were located in quadrant 4 and received a score of '4'. Using this metric we have conducted preliminary comparisons between 8 classes in the US and 5 in Foshan (Figure 7). Overall there are more variations between the classes than across the countries.



**Figure 6.** Defining Problem Solving Efficiency and Effectiveness. a) Plot of the average SEI of student performances vs. the solve rates where students performed 4-30 cases of middle school IMMEX problems (n~30,000 performances). b) Definition of Quantitative Value (QV) based on the vertex created by the average SEI and solve rates for the data population.



**Figure 7** Quadrant Scores of Schools in China and USA. Schools designated with a \* (372) are from Foshan China and the other four are from the US.

### Discussion

Overall the workshop satisfied the initial goals and exceeded the expectations of the participants and members of both the China and US team.

Having a balanced team was important, particularly as both teams hoped that teachers would implement the simulations during Spring 2007. The IMMEX team included a veteran classroom teacher who has extensive experience in using IMMEX and conducting professional development workshops, several technical support personnel who were experts at the technical aspects of IMMEX and also spoke Mandarin, several logical support personnel who provided documents and handouts and gave presentations as needed.

Finally there was a cultural liaison who was knowledgeable about Chinese customs and procedures, spoke the language and also understood how IMMEX worked in the classroom. This team was able to meet the diverse needs of the workshops and provide technical and cultural advice to the China team that formed the core of the advisory group.

As the collaboration went forward both teams experienced (pleasant) surprises. These included the ease with which the school district and the principals embraced the proposals, and the similarity of the school systems in the manner they are driven by the same expected outcomes, i.e., teaching to the test within the cultural norms. A third surprise was the ease with which the students engaged in problem solving in a second language. And finally the technology infrastructure at each site was excellent with regard to equipment, software and personnel.

Asking teachers to make changes in their expectations of students by prompting students to try solving a problem without first providing detailed instructions on how to succeed is among the greatest challenges the IMMEX team faces. The teachers are comfortable providing instruction that allows students to get answers easily. Teachers provide general guidelines in problem solving in math and other content areas, e.g., multiply and divide, then add and subtract. Similarly, there are general guidelines to solving IMMEX problems: understanding the question to be solved, knowing the content area of the problem well and using the informational resources within the problem space, then, making a hypothesis about what the answer might be or at least what additional information might be useful, evaluating testing, and then proceeding. These steps are easily described and well understood as part of the scientific method. Students may have memorized the scientific method but do not get a lot of practice, especially where they can revisit the same problem. Lab exercises generally do not provide for multiple repetitions with multiple procedures. And unlike typical classroom activities the student must decide what information is relevant in an IMMEX problem.

To use IMMEX effectively the teacher needs to use a different instructional approach. The teacher needs to know the answer to the student's question but not necessarily provide it. Rather the teacher needs to guide the student in the first steps to the student's answer, e.g., "What is the problem you are trying to solve?" or "What do you know so far?" or "What information is important and why?" These are sample questions that could be asked after talking with the student and determining what the student knows, in terms of content understanding and experience with the problem set. The goal is not to give the student the answer but to guide their skills in problem solving. The teacher needs to allow the student to make mistakes, even as the teacher watches it happen. The student will learn from their mistakes because typically there are two chances to solve a case and the cases in a problem set are similar. Also problem solving will be improved if, after a case is solved, the student downloads the Strategic Performance Map and reflects metacognitively on their choices. This can be facilitated by small group and whole classroom discussions and guided questioning. This strategy requires more time at the beginning of the process. The reward comes later on when the student begins to apply these same strategies to other IMMEX problems and to other content areas and problems that need to be solved. The reward also comes because the student more deeply understands the content embedded in the IMMEX problem space,

The results of the pilot study from China illuminate these very issues in the classroom and demonstrate the need for further professional development / instructional strategies for the teachers. These have been summarized below by the partners in China in their summary report to the Chancheng School District. After initial analysis, it is determined that IMMEX has a positive effect on students.

- IMMEX can help teachers identify the students who most need help (Table 2).
- The advisory group believes that the teacher needs to have clearer guidance for the students who study hard but have low academic achievement scores. These students need help to overcome the difficulties in learning such as understanding of basic definitions and comprehension of math processes, etc. IMMEX helps the teacher to more accurately identify what the learning difficulties are for these students.
- The advisory group believes that the teachers need to pay attention to identifying students who have high academic achievement scores but low learning efficiency. The difficulties these students have are masked by their high academic achievement scores and can be easily overlooked. Therefore, the opportunity to promptly correct the student is often missed when they encounter barriers that cannot be overcome by plain hard work. IMMEX can help the teacher in easier identification of these students.

- The advisory group discovered that for the student to complete as many cases as possible in a short period of time is not an effective way to improve the problem solving skill for the individual. The skill improvement is more significant in an environment with teacher's in-depth guidance and repeated discussions in small groups. Therefore, since the problem-solving process is the most important element in IMMEX, at least a certified teacher is needed to conduct the guidance.

Table 2. Performance expectations by skill level.

Problem solving efficiency-IMMEX/China	Academic Skills	Academic Skills	Academic Skills
	Low	Medium	High
Quadrant 1 guessing	Expected	Not expected-need help in problem solving skills	Not expected-need help in problem solving skills
Quadrant 2 confused	Expected	Expected	Not expected-need help in problem solving skills
Quadrant 3 Good	Not expected- need help in classroom skills	Expected	Expected
Quadrant 4 Excellent	Not expected- need help in classroom skills	Acceptable	Expected

## Endnotes

- (1) "One World One Dream" fully reflects the essence and the universal values of the Olympic spirit -- Unity, Friendship, Progress, Harmony, Participation and Dream. It expresses the common wishes of people all over the world, inspired by the Olympic ideals, to strive for a bright future of Mankind. (<http://en.beijing2008.cn/17/74/article212027417.shtml>)

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