

How Teachers Use IMMEX in the Classroom

Eva J. Chen, Gregory K. W. K. Chung, Davina C. D. Klein, Linda F. de Vries,
and Bruce Burnam

National Center for Research on Evaluation,
Standards, and Student Testing (CRESST)
Center for the Study of Evaluation (CSE)
Graduate School of Education & Information Studies
University of California, Los Angeles
301 GSE&IS, Box 951522
Los Angeles, Ca 90095-1522
(310) 206-1532

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HOW TEACHERS USE IMMEX IN THE CLASSROOM

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Abstract

For the past two years, CRESST has been conducting research to evaluate how middle and high school teachers integrate the computer program Interactive MultiMedia Exercises (IMMEX) into classroom learning. The IMMEX software provides students with educational problem scenarios in science and other fields, requires them to use problem-solving skills and integrate concepts with real-life situations, and allows teachers to evaluate student content knowledge and reasoning skills by using the search path maps generated by the software. For the 1999-2000 year, CRESST researchers have collected qualitative data to answer the following two research questions:

1. How is IMMEX being implemented and integrated in the classroom for instruction and assessment?
2. What is the impact of IMMEX on teachers and students?

In spring 2000, we interviewed eight teachers who had the experience of using IMMEX for at least 1 year. Data were collected on teachers' experience in using IMMEX, the perceived impact of IMMEX on student learning and classroom instruction, the barriers teachers encountered during implementation, and suggestions they had to improve IMMEX integration.

From our interview data, we found that IMMEX could be a potential source for both teacher assessment of students and the students' development of self-assessment. Most teachers reviewed search path maps and discussed IMMEX-specific and general problem-solving strategies with their students after an IMMEX activity. Some teachers claimed that discussing the search path maps with the students helped them examine closely their thought processes and problem-solving skills. Other teachers used IMMEX to assess certain abilities such as problem-solving skills or creativity that may not be recognized through traditional methods of evaluation. IMMEX was also regarded as a useful tool in evaluating the real

abilities of those students who were lacking in English skills or who were from disadvantaged backgrounds.

Some teachers found that IMMEX could fit well with the curriculum standards and many used it to supplement their curriculum. In general, we found that teachers were more likely to implement an IMMEX problem set which could match and reinforce the content they intended to teach. Other teachers integrated IMMEX because the problems were complex and interesting enough to challenge students and increase their motivation. Working on IMMEX required the students to actively integrate information and materials, which, according to the teachers, helped the students better understand and retain the content knowledge.

Teachers also used IMMEX programs to connect school learning with the outside world. They pointed out that becoming involved with IMMEX problems not only enabled students to apply what they had learned in class, but also increased their appreciation of the importance and relevance of the subject matter. The students could see that what they were learning would prove to give them skills which would be beneficial to their lives beyond the classroom.

Some teachers claimed that IMMEX was effective in engaging students in learning activities since students were able to take the initiative and get actively involved in their own learning process. Some of the interviewed teachers observed a significant increase in students' motivation in learning. IMMEX appeared to work especially well with students who had been low achievers in school. Other teachers indicated that IMMEX use had resulted in increased student interaction and collaboration. Teachers were excited to see students challenging each other and constructing knowledge together. Increased student self-exploration and collaborative work have also changed the role of some teachers in the classrooms—from being the sole knowledge providers to being the facilitators of a community of learners.

Introduction

The IMMEX (Interactive Multi-Media Exercises) effort began as a computer software program developed at the UCLA Medical Center for assessing the diagnostic skills of medical students. Over the last decade, IMMEX has moved from software designed exclusively for medical students to a flexible assessment system used in secondary and college-level settings. The general procedure embodied in the IMMEX software is to prompt students with a problem scenario and then to provide them access to information that is both relevant and irrelevant to solving the problem. Students are given information that they must interpret in the context of other information and the problem stimulus. To solve IMMEX problems successfully, students must identify and use relevant information as evidence or data, drawing appropriate inferences and conclusions. IMMEX software is also capable of monitoring each student's information-gathering behavior and then representing this behavior graphically, by recording the order and time spent on each information source and translating this information into a network representation. By inspecting the graphical depictions of students' search paths, teachers can get a picture of the problem-solving strategies of one student or of the entire class.

Through its summer institute, the IMMEX software development staff trained over 300 teachers on how to use the program for supplementing curriculum and conducting student assessment. Since fall 1998, CRESST has been conducting research to evaluate the implementation, integration and impact of the IMMEX software in school settings. In spring 2000, CRESST continued its year 2 evaluation work and qualitative data has been collected to answer the following two research questions:

1. How is IMMEX being implemented and integrated in the classroom for instruction and assessment?
2. What is the impact of IMMEX on teachers and students?

Research Methodology

We interviewed eight teachers who had used IMMEX for at least a year. The subject areas these teachers taught included biology, science, math, and computer technology. The students of the interviewed teachers were in Grades 8 to 12. The teachers were contacted by field researchers through faxes and phone calls to arrange for interview times that were convenient for them. All the interviews were conducted in the schools and tape recorded with the teachers' permission. The length of the interviews ranged from 45 to 60 minutes. Data were collected on teachers' experience in using IMMEX, the perceived impact of IMMEX on

student learning and classroom instruction, the barriers teachers encountered during implementation, and suggestions they had to improve IMMEX integration (see Appendix A).

All of the eight teacher interviews were transcribed and the transcripts were coded with a list of codes created based on the research questions, the key concepts of this study, and past research on evaluating technology use in schools. As the coding process progressed, we continued revising and developing codes, combining them or expanding them with subcodes. Categorizing analytic strategy was utilized to sort the coded data of all teachers into major categories. The process of coding opened up inquiry, and categorizing and clustering data facilitated the development of themes and concepts, generating an overall picture of how the teachers had been using the IMMEX program in the classrooms. For example, in terms of how the teachers used different strategies to integrate the IMMEX program into curriculum, we developed subcodes to categorize their specific integration efforts (e.g., for assessment, for content reinforcement, for introducing background information, etc.) and subcodes to understand the perceived impact claimed by teachers (e.g., improved student behavior, increased student motivation, enhanced student problem-solving skills, etc.). Analysis was carried out to examine the different kinds of integration styles teachers used and how their integration strategies were related to the perceived impact of the IMMEX programs.

Research Findings

How Teachers Integrate IMMEX Into the Curriculum

IMMEX Use for Content Enhancement

Supplementing curriculum. A major concern of the teachers using IMMEX in the classroom continues to be the integration of the programs into their curriculum. Currently there is a high priority throughout the state requiring that teachers present a given content to the students which is in line with set curriculum standards. Thus any program or supplementary material that will enhance the students' understanding of the content will be considered in a positive light by most teachers. A majority of the teachers using IMMEX who were interviewed now feel that this is one of the strongest points of IMMEX, since the structure and content of most IMMEX programs enhance content knowledge, while aligning positively with the curriculum standards:

The standards for California are almost all vocabulary. Can the kid distinguish between these different parts of photosynthesis? So, it's a lot of vocabulary, it's a lot of thinking connections between processes. And all IMMEX does is go one step further than the standard. So you see, give the kid the bag of tricks, and then apply the bag of tricks on an IMMEX problem. So it meets the standards in that they're applying the information they're supposed to be getting.

Well, I suppose some teachers could make that statement, that they can't do it because they don't have time. They need to focus on the standards. But then what they're saying is, "I don't care if my kids can use the information that the standards are requiring them to have. I just care whether or not they get exposed to the information." See that's, that is the dither with the standards. Is it about exposure or is it about application? Can you, do you want the kids to just know it, or do you want them to be able to use it? Because they'll just know it for as long as they are required to. Until the test is over, until the exam is done. If they can use it, hopefully it will stick with them longer.

Our finding that the teachers focused on using IMMEX problems that corresponded to their curriculum is consistent with results of past research in computer integration in the classroom. Numerous studies have indicated that teachers tend to judge the usefulness of the computer by how it would fit into their ongoing classroom practice and the already established curriculum (Knupfer, 1993; Pea & Sheingold, 1987; Schofield, 1995; Wiske, Niguidula, & Shephard, 1988). As Wiske et al. (1988) pointed out, following the syllabus and covering the required materials were regarded by teachers to be their primary responsibility. New technology and innovative teaching which "directly address core

elements in the existing syllabus are more likely to attract the interest and cooperation of teachers” (Wiske et al., 1988, p. 59). In general, teachers’ major concerns about computer use in classrooms were the level of difficulty of the software, the precise subject materials it covered, and the way the software meshed with their textbooks (Schofield, 1995). We found the above claims to be true with the teachers in our interviews, who would not use IMMEX to any noticeable extent if they did not feel the program could contribute to the attainment of their goals. Therefore in classroom integration, the goal of using IMMEX was not to facilitate fundamental changes, but to help teachers do what they were already doing more easily, efficiently, and effectively.

As the IMMEX teachers took an “incrementalist” view (Schofield, 1995) of computer integration, they adopted various strategies to incorporate IMMEX into their structured daily instruction. Two teachers mentioned the use of IMMEX problems as an ancillary activity which would be given to students for diversionary or extracurricular purposes, or as an introduction to technology. And all but one agreed that the IMMEX problems should be given in a supplemental manner following a traditional presentation of the content. After the content is understood by the class, the teacher would then follow with a contextually appropriate IMMEX problem to reinforce what had been studied, and to enhance understanding of concepts and applications.

The teacher who favored use of IMMEX as an extracurricular activity stated:

I don’t use IMMEX to guide the curriculum. I use IMMEX to provide alternative activities to the curriculum. I don’t want them to, I don’t want IMMEX to necessarily change my curriculum

Apart from the fact that IMMEX programs could match the standards, the teachers indicated other reasons to use IMMEX to supplement curriculum. IMMEX problems offer an additional tool which can be used to present the subject matter to the students in a unique and interesting manner. The IMMEX problems were complex and interesting enough to reach out and challenge many students, thus increasing their motivation and engagement. Teachers also found that students were required to actively integrate information and material to which they had been exposed as they sought to solve the IMMEX problems. The students could better understand and retain the content knowledge when they actually were given the opportunity to apply the concepts and information. Thus IMMEX created a learning environment where teachers could encourage “spontaneous” learning (Piaget, 1973)—a learning process in which students could construct knowledge through self-discovery to achieve conceptual understanding.

The IMMEX problem is generally a reinforcement of the concepts.... Most of the times, we've already gone over the content in class, through lectures, activities, labs, and so forth. And then the IMMEX problem solving is there to reinforce, hopefully, what was learned. In some cases, I have used it more as a learning experience. Let the students work their way through the problem space, and try to assimilate information that way.

During the unit there's a point where you're building a knowledge base. You know, you're giving them a vocabulary, giving them some skills, and trying to help them make connections. And that takes a bit of time. And then they become more familiar with the material. They start to use the vocabulary. And then you want to give them more challenges. And that's when an IMMEX problem makes sense, because then they're going to have fun with that. They already have some of the vocabulary, they already know a few of the connections, and getting a chance to apply that knowledge in a problem-solving activity.... So that's why I think of it more as a culminating activity.

It appeared to be a common practice to use the IMMEX problems as an additional tool for reviewing content or reinforcing concepts. While time constraints sometimes limited the actual use of IMMEX, the teachers often tried to present a problem more than once, or to include clones to enhance content knowledge. They often would utilize tools, such as the menus, libraries, and experiments, to review, supplement, and reinforce the content matter. Other teachers would then add classroom activities which would increase understanding of the IMMEX problems while reinforcing what had been learned.

I really like Roots Quest and True Roots. I think it works really well with the students because we studied everything on genetics and I use it as like the last piece where they can see why it is important to know about Punnet Squares and blood testing and things like that. So it is very useful. And High Life that was something I connect through in with my ninth graders, because we were working on drugs and it has to do with drugs.

The one that I really focus on is True Roots. We do a lot of activities before they use the program, like we do karyotypes: They do some worksheets on karyotypes and they cut out chromosomes and make a karyotype. And they also make their own pedigrees, which they take pictures of everyone in their family and kind of make the pedigree and follow a specific trail. We do some projects beforehand and then we learn about genetics and then we take the program. And I usually teach it in such a way that I teach the content first and then the students get to get on and do some work on IMMEX.

The content was taught in the first semester. Most of them got it and again that is the thing about True Roots, even if they haven't been exposed to that content before, than a brief check to the library will remind them. I don't think the library can teach somebody who doesn't know anything

about it. But if they know a little bit about blood types and fingerprints, then the library is pretty good in teaching that.

In addition to using specific IMMEX problems for review, one teacher even used them to supplement, and even at times replace lab exercises, since she found the skills and knowledge learned in certain IMMEX problems were equivalent to what the students would learn in actually completing the lab assignment.

In the AP Biology class, there are several of the problems that are concurrent with the lab. There are 12 required labs for the AP class. In two cases, I used them *in lieu* of the lab.

Those are lab exercises, and I use it the same way that I do their regular lab exercise.

Rocks is used as the warm-up for the lab exam. The lab exam, they have 24 minerals they have to know by test. And so by using IMMEX, they were able to practice it, and they could work through multiple problem sets.

Teachers would also use the IMMEX problem for introducing additional concepts, applications, or new learning tools which would enhance the students' understandings. Other tools or activities could be worked on simultaneously with the IMMEX problems, thus giving the students additional skills and knowledge.

There were teaching moments because one of the menus was to determine, or it shows you what substance was found in the blood and it gives you chemical formulas that don't tell you what it is. So that was an opportunity even though we hadn't had that at that level. It was an opportunity to show them where the chemistry books are and have them look at, you know, use the index, look up the formulas. Because I noticed there was also a menu with molecular weights and stuff. So there were teaching moments in it.

Bringing the real world into the classroom. Many educators advocate that classroom activities should be related to the student's experiences, interests, and goals (Dewey, 1938; Anderson, 1978), that the most effective educational environment is one which provides for engagement in the types of activities that are required and valued in the real world (Pea & Sheingold, 1987; Brown, Collins, & Duguid, 1989), and that students should be provided with a framework of learning in which they can understand the cultural significance of the facts and their relation to other facts (Lave & Wenger, 1991). In our evaluation, the teachers repeatedly emphasized the value of IMMEX problems in providing real-world applications and understandings of the content. They pointed out that becoming involved with IMMEX problems not only enabled students to apply what they have learned in class, but also increased their appreciation of the importance and relevance of the subject matter being

learned. And connecting school learning with the outside world through working on IMMEX increased the interest of many students who otherwise might not be that involved in educational activities. Students now were able to see how they could apply the material they had been learning, whether in science, mathematics, or history, to the real world. Otherwise disinterested students could see that what they were learning would prove to give them skills which would be beneficial to their lives beyond the classroom. This is especially significant for lower level or marginal students, who might have little interest in school. However, it also can become a motivating factor for higher level students, who learn to apply what they have learned in real life, problem-solving situations. Teachers interviewed found that students in AP and Honors classes were interested in taking the knowledge they had learned in textbooks, lab exercises, and lectures, and applying it to real-world situations and problems.

When we do IMMEX students enjoy the content more, because they see the relevance.

They are not only, they are addressing the content that is in the classroom, but they are also addressing things that are out in the real world. Things that they are run into often.

I think the IMMEX problem kind of shows why it is really important to learn about technology and to know about some things in genetics.

Working with inner-city students from varied backgrounds and lower socioeconomic environments, some teachers focus on finding ways to motivate and involve the students. An example of a vocational program that seems to encourage students to become more actively involved in the learning process is the health academy located in the Pasadena School District. Gaining life skills and applying them through actual involvement in real world jobs are motivating in themselves for these students. But when they can use the subject matter while solving real life problems, the value of learning otherwise difficult subjects such as biology, physics, geology, or chemistry takes on a new sense of importance. The tedium of studying facts out of a textbook is now looked upon as an important part of the learning process, as that which is learned will enhance the knowledge and skills of the students in a way that can be applied in their actual lives and vocations.

Because you have to solve problems and you know I have students who are working at Wetzel's Pretzels and they are like, "What does this have to do with anything?" So when you are talking about customer service, when you are talking about measurements of the dough and the temperatures and all the ingredients and letting it rise and how much does the dough weigh and you know the average pretzel.... So they have to think and problem solve, so if teachers can bring that to life for them. Because right now everybody thinks they just do this, they don't know what

it is called and it is thinking in problem solving. Critical thinking. So the teachers have to always remind the students, what it is they know.

It's (Island Survival) real life. And then when they get to their island, they have to solve water, the first thing they have to do is find a water source. So we have water chemistry to do: bonding, hydrogen ionic conversion, and so forth, while we solve the water problem. Once the water problem is solved, then we can start setting up our research camp. And move from the boat to the island, which involves building a shelter, which means we have the physics of gravity, and structures, and weight supports, mechanics. And in the meantime, they're setting out to do their baseline studies: biological, soils, climate.

In Part 1 of this report, a teacher discussed how IMMEX problems helped bring to life a major study of communicable diseases for students in the health academy. Real life instances of the Ebola virus and other epidemics were discussed, films like "Outbreak" were observed, and the IMMEX problem, Creeping Crud, was introduced. This problem required the students to solve an infectious outbreak, while learning the effect of certain substances on the body. The students were encouraged to utilize and apply knowledge learned in biology and chemistry. The result was total involvement and enhanced understanding of real-world problems on the part of the students participating. The two teachers in this program have again incorporated IMMEX into another unit involving the use of drugs. The students were involved with a project regarding drug abuse, and the introduction of the IMMEX problem, High Life, "perked their interest to delve further into drug use and abuse." This was especially interesting to all students, because the use of drugs such as marijuana, cocaine, and heroin have become a significant topic of concern and discussion for high school students. In this case, interesting and often heated discussions broke out. One student even told of an incident where she was selling candy to sixth-grade students, and one student bought candy from money which was pulled from a marijuana bag. Counselors and speakers were brought in to further the students' knowledge of drug use and abuse. Obviously, the topic of drugs was one which connected real-world activities which interested students to the curriculum of biology and chemistry. The integration of High Life is a good example of how teachers can organize instruction around real-world problems in order to induce orientation to learning that is congruent with subsequent knowledge use. According to the teacher, the presentation of relevant, real-world issues resulted in increased students' involvement in the subject matter.

Past research has demonstrated that students should be encouraged early to appreciate the full richness as well as the complexity of the problems of practice to ward off overly simplistic orientation of learning and understanding of a subject matter (Barrow & Feltovich,

1978). Teachers found that IMMEX could bring the real community of science into the classroom. Students could get exposed to the realities of the field, while applying the concepts they were learning to real-world situations.

It helps them visualize it. Most of my lower end kids, particularly my immigrant kids, have no science or college-educated people in their family background. They think college is going to school at 8:00 and coming home at 3:00, and everybody takes roll every hour, just like we do. They have no idea it's any different. And most of them don't know what an engineer is. He drives a train. That's as far as we get, kind of a thing. So they have no exposure to what scientists do and how much fun it really is. So this is one place where they can really find out.... And the actual steps by which you have to do [IMMEX], and the various other sciences involved in so doing is quite an item for them. And some of them find they don't think they'd like that, and others think it's really neat. And think of careers they might not have ever thought of.

The solving of real problems.... A lot of science at the lower levels is memory. It's not exciting at all. You don't apply any of it to anything. And yet here is something exciting going on, that they figured out. They're going to send first aid by the Red Cross, depending on where the earthquake was. And they had to do all the science to tell the Red Cross how we could help people. So we're seeing a connection between what research does, and how it's applied in the field. The same thing with the... other ones on True Roots. Well, here's a genetics problem. Here's a person who's got the problem, and now we're helping them solve it. With Antibodies and Lost at Sea and all the others, here's a real problem, and how science actually works. And, you know, maybe that would be an interesting career. I don't want to spend my life sitting here memorizing textbooks.

Summary. Therefore it appears that IMMEX problems can prove beneficial to educators who have been properly trained in their use. They bring real-world, relevant, problem-solving activities and situations into the classroom that complement and supplement the content being taught. Students gain an understanding of the relevancy of complex subject matter, while learning how to proactively apply concepts they have learned through traditional methods, such as textbooks, lectures, lab exercises, and assignments. Another important finding is that the problems not only appear to align with the content standards required in all classrooms, they also give the students requisite skills that might enable them to improve their abilities to do well in standardized tests. IMMEX problems also pull some students on the fringe or at risk back into the classroom due to their relevancy and real-world focus.

IMMEX Use for Assessment

As the teachers integrate IMMEX into the classroom, a significant concern is figuring out how to use the program as a tool for assessment and evaluation. With the development of

search path maps, IMMEX becomes a potential source for both the teacher assessment of students and the students' development of self-assessment and metacognitive skills. In their interviews, many teachers discussed the importance of having such an additional tool for assessing students, but only one was actually using IMMEX in actual assessments. Others stated that they either did not have the time or training to enable them to incorporate IMMEX into their curriculum as a tool for assessing students. Some teachers had tried to use IMMEX programs to help students build metacognitive and problem-solving skills, which is an increase since the time of the first interview in November 1999. The teachers recognized the value of IMMEX as a potential tool for assessment, not only of the students, but of the effectiveness of their own teaching.

Tools for assessment. Teachers have identified several tools that can be used in conjunction with IMMEX that will enable them to better assess the students' understanding and progress. The search path maps which come with the problems, though often not available as soon as the teachers would desire, helped both the teachers and the students ascertain whether the problem was correctly solved, and what patterns of logic and reasoning were followed in attempting to solve the given problem. But the teachers often appeared to use supplemental tools to gain further insights into the thought processes of the students. Many used either study guides or notes, which must be filled out while the students were working on the IMMEX problem. The notes were especially beneficial when more than one student was working on a computer, since the search path maps could not reflect the individual patterns and thoughts of each student. Even walking around, observing the class, and interacting with the students have given some teachers a sense of where the students were. In addition, some teachers then discussed the search path maps and problem results with the students to gain further understanding as to how the students were thinking. These supplemental sources were heavily relied upon by a number of teachers who still felt they did not yet have sufficient knowledge and experience in working with the computer-generated search path maps.

A student guide or a study guide.... It is a guide that they follow to solve the problem, write the problem in their own words, so they fill out this study guide or student guide. And after they do I evaluate this.

If there are two students or three students working on one computer I don't use the map for evaluation, I just use the notes. Because I ask them, everyone should take the notes, I don't care if there is three or two on one computer.

With all of them, whether it's a lab or an assessment, I get out the search path map and look to see if it's a logical approach. And then I look at their notes to see if there's any addendums that would modify what the search path map said.

Every student would get a template like this and they would put their notes in accordingly.... So you would look at their notes and say well do you really need to know the prices of the shoes for each single person or... if you eliminate that how come he is still here, you know what I mean, if he definitely wasn't the person involved, then why do you still need information about him. So we would talk about things like that and then look at this and say how much time it took and how—I am not sure what the menu items are for, but—like say, this were like library. How come you didn't know this information very well, you had to go to the library. So you would be able to tell that they didn't know much of the content.

Assessment tool for certain students. Teachers have begun to find value in IMMEX as a viable tool for assessment. Students who may come from disadvantaged backgrounds may present problems in trying to assess their real abilities and skills, especially if they are lacking in English skills or come from environments which may not value education. However, one teacher found that IMMEX has proven to be a valuable source in assessing certain abilities such as problem-solving skills or creativity that may not be recognized through traditional methods of evaluation. The skills necessary to solve IMMEX problems involve characteristics that at least several of the teachers found to be difficult to assess using standard classroom techniques. In fact, it was through doing IMMEX problems that one student who spoke very little English and struggled with traditional tests was able to shine and demonstrate an exceedingly strong aptitude in higher order thinking skills.

I think the search path maps, having that available as data has helped a lot. And there's so much data that is available [that] you can sort or filter that data in so many ways to give you an idea of where the kids are. And that's very helpful, because I find that grades are not that great a data source. A kid can get an "F" and still have really good problem-solving skills. A kid can get an "A" and have no problem-solving skills. So it's like another data source that gives a different picture of the kid.

Not all of it is lack of mental ability. Some of it is lack of schooling. Many kids from war torn countries that have come in who haven't been to school for awhile. And so they've missed all of these skills in between. And about the only place you can really make an assessment, how to separate not knowing the language and lacking ability.... You don't know where to attack the problem. But IMMEX really points you in the direction of what his problem is. The problem is reading.... You see that because the logical progression is all there, so he's thinking well. You'll see those people go to the vocabulary and the dictionary often. But their logic progress is good. So it's okay, we understand, and we think, well, there's a vocabulary problem. And they put that in

their notes. Because I have them write down words they don't understand, so we can amend dictionaries for anything that doesn't show up.

Strategies for assessment. Several teachers presented strategies for incorporating IMMEX into the class as an assessment tool, even though only one actually graded the student search path maps and notes. One felt that she was better able to get a grasp of the students' progress and knowledge by giving a content-related IMMEX problem to the students in fall 1999, then giving clones of the same problem or similar problems again in spring 2000. The students would go over their results and discuss their strategies the first time, then go over the problems again in the spring using the same format. The teacher could then use the search path maps, notes, and student discussions to ascertain whether the students had progressed in both content and problem-solving areas.

I have used it in my class, twice. And we did High Life in November, which was the benchmark. And then we redid the program in March. So I am looking now at the search path maps and for the first time, I am really making a correlation between students, because before I just ran the problem and got a search path map. Now, this is the same problem and I can sit down and I can look at the one from November and the one from March, and I can see, it is the first time I can really analyze that search path map and figure out what it is they did.

I gave them back individually, and the thing that's been very effective is I give the search path maps back, stapled to their notes, with my comments on it. And if the students disagree with my assessment in terms of the grade, then they have to come up and show me where, what I suggested was not valid.

They have to think about what it is about what I was thinking. And a lot of times they will. They'll say, "Well, no. It shouldn't have been this way. And this is what I was thinking." And they'll come back and explain it. And generally speaking, if they're willing to come and explain, I'll give them some more points anyway. Can't give them out too easily, or I'll get many more people trying.

Some teachers who used IMMEX for assessment would introduce the concept of problem solving and search path maps to the students in open class discussion, while others would just pass the notes, study guides, and search path maps back to the students. In doing the latter, the teacher would have to hope that the students could figure out on what they had done and why they had succeeded or not in solving the problems. Since only one teacher graded the problems, there might be a question as to whether the students would understand what they had done or whether they could develop strategies to enhance their problem-solving skills, content knowledge, or understanding of what they had done. Thus it is

significant for the teachers to offer interventions and discussions, if they are to assess student progress and understandings involving IMMEX problems over time.

And we talked about what a search path map is and how it shows the different menu items by color and how it shows the time it takes to finish it. So I think that helped them and helped me in the sense of assessing them.

When those search path maps are back, I go over them in class, and hold this one up and say, "Well now this is what this person is doing." So the students all know what the search path map looks like before they do it for assessment. They know how I grade it.

Each student reviews their search path map, looks at what they've done. We discuss how the class did as a whole. What were the common strategies? We do it with oral discussion. What were the common strategies that were successful? What were a couple of strategies that weren't? And then I want to make sure that they really understand why that didn't work.

When we get the first search path maps back, I spend a little more time kind of going over just what it's showing and how it's color-coded, and try to get them to remember what they were doing. Remember the menu items, and they were grouped in a certain way, and so forth. Well, this is now a hard copy of that menu structure in terms of what you selected, and the sequence you selected them in. And those that have a straight line from start to solution, I just tell them, you know, you sort of guessed, right? Because they don't really realize that the computer is tracking their selections until they get the search path map back.

Assessment to develop metacognitive skills. While the teachers do seem to be trying to find ways in which IMMEX can be used as a classroom assessment tool, they also have been focusing on the use of this problem-solving program to enhance student self-assessment and metacognition. One teacher would give the problems back to the students along with their search path maps, and have them analyze their own strategies. This was the teacher who actually did assessments, and she would then adjust the grades accordingly if the students could logically discuss their thought patterns, strategies, and what they might have done or might do in the future. The teacher claimed that such actions enhanced the student's metacognitive skills. One teacher working primarily with AP students had the students actually dissect their own search path maps and write down a critique of their thoughts and strategies. But he made no efforts to assess or evaluate the students, instead relying on student initiative and self instruction. Since the teacher never followed up on these analyses, any resulting improvements or changes would be hard to identify.

By getting the students involved in the process of analyzing the successful and not so successful strategies of solving the IMMEX problems, the teachers hope to enhance the

students' understanding of their own reasoning and thought patterns, while encouraging them to improve their problem-solving skills. When done in a methodical manner, with the teacher developing interventions to go over the students' search path maps, notes, and other learning tools, IMMEX appears to become a viable source for developing metacognitive skills in students, which can lead to an improvement in learning and problem solving skills.

Yeah, my main goal for using them is for the kids to see... how their own mind works. What their own process is for solving a problem. I want them to be metacognitive.

But when she was given a chance to analyze her search path maps, and compare them to what sort of an ideal would be, where you're trying out a lot of things, and then narrowing down, her skills improved a lot. And her search path maps looked a lot better the second time. And I think that was just because she would meet any standard you gave her. She just didn't know what that standard was the first time, and then she's improved a lot since then.

I had overheads of several people's search path maps. And I showed them the sequence. This was the first one they did, and the first one they went through almost every menu item, and it was all scattered. It wasn't like organized. They just tried out this one, and then tried out this one. And then the next one, they narrowed things down a little bit more. But then by the fourth or fifth one, they were guessing. They were going to one thing, and then going to "Solve." So then they weren't even investing any energy in the process. So we went over those kinds of search path maps, and tried to analyze what was going on in the person's head based on the search path map. And then the kids were anxious. They wanted to see what their search path maps were. Because they wanted to see how they had done. So I gave them their stack of search path maps, and they had to write a little paper. Just answer a few questions.

Examples of students using IMMEX for self-assessment. Figure 1 and Figure 2 display the search path maps generated by IMMEX for two students who worked on the Island Survival problem in a high school AP biology class in September 1999. To the right of the search path maps are the journals the students wrote while they were examining the search path maps. The maps illustrate the individual steps the students took in gathering information to solve the problem, and the journals reveal how the students critiqued and reflected on their problem-solving strategies with the visual display of the search path maps.

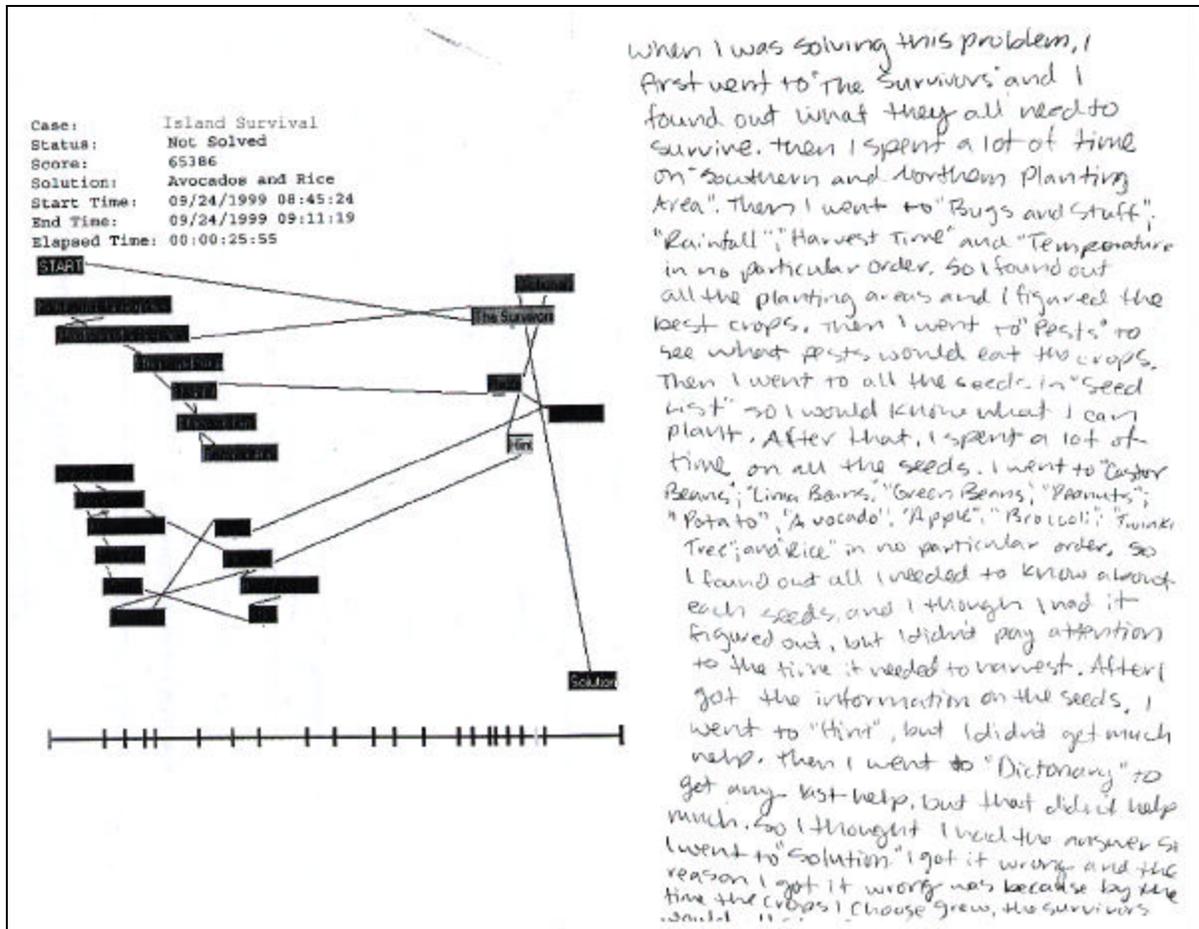


Figure 1. First example of a search path map for Island Survival.

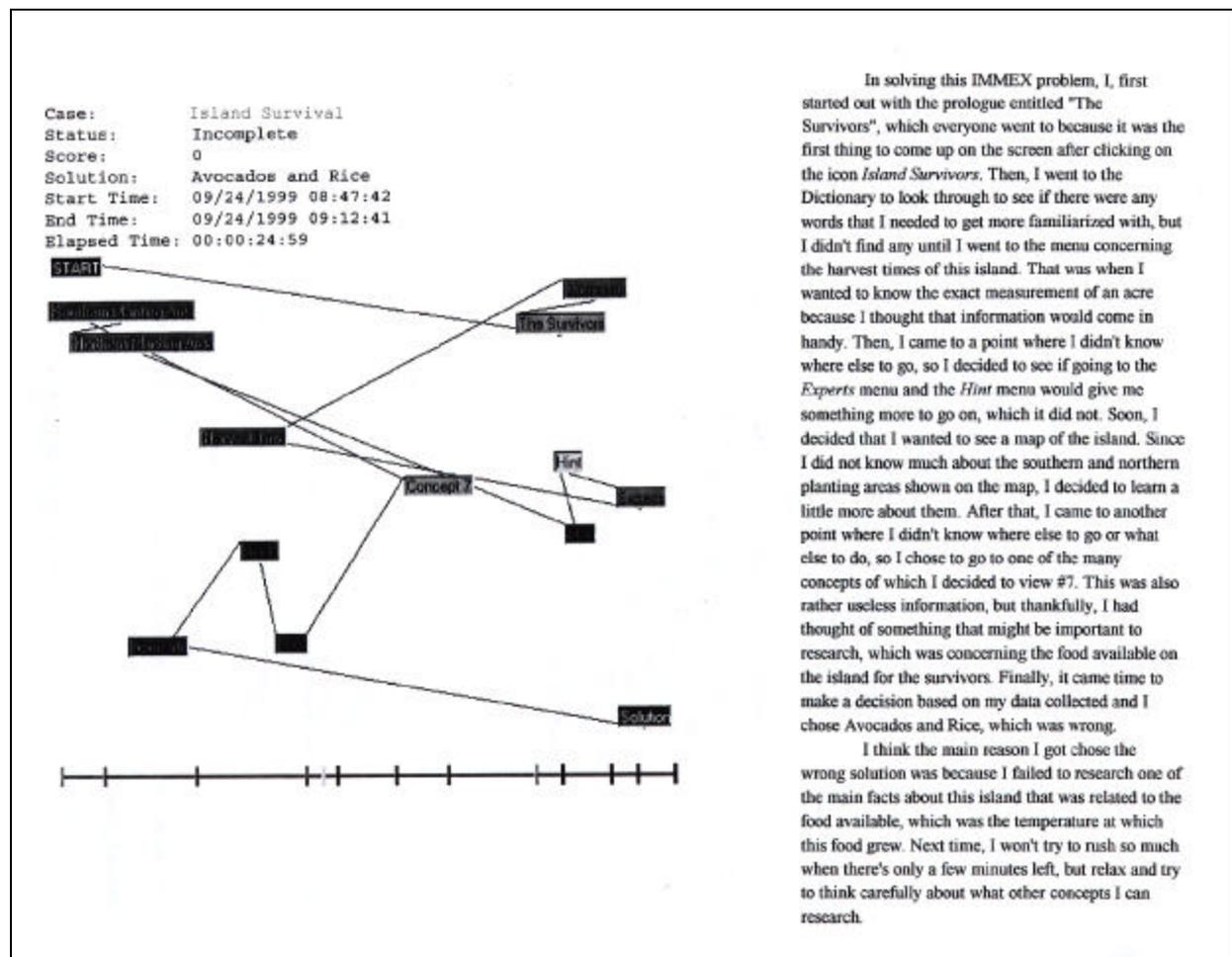


Figure 2. Second example of a search path map for Island Survival.

By analyzing the journals, we gained a better understanding of the thinking process the students engaged in and why they succeeded or failed in reaching the right conclusion. For example in Figure 1, the student first retrieved the information on what the survivors needed on the island. With that information in mind, the student searched for the best crops that would help people survive on the island by learning about the soil, the pests that could destroy the crops, and the seeds for planting. After discovering that the "Hint" and the "Dictionary" were not particularly informative, the student made the decision to choose avocados and rice. The answer was incorrect and by examining his/her strategies, the student realized that the time needed to harvest was a vital factor that he/she had ignored. With the search path map, the student could not only recall what strategies he/she employed, but also examine and explain why the strategies were successful or unsuccessful. The self-evaluation process enabled the student to scrutinize his/her thought process, to achieve a deeper understanding of the content knowledge and to develop new problem-solving tactics. In

Figure 2, after analyzing the logic he/she had taken to reach the solution, which was wrong, the student realized that because he/she was hasty, he/she had neglected the temperature at which the food grew on the island. By self-assessment, the student learned that thinking carefully and researching other concepts would be the strategies to adopt in the future.

Figure 1 and Figure 2 are good examples of how teachers can use IMMEX to encourage and train students' acquisition of thinking processes which are distinct from content knowledge. The distinction is captured in the terms of "object knowledge" versus "process knowledge" (Chen & Paisley, 1985). Different from object knowledge, which is subject-matter knowledge, process knowledge is the ability to specify why to formulate hypotheses, interpret information, ponder causality, reach conclusions—the ability to think about one's own thinking. When students worked on IMMEX problems and subsequently, when they conducted self-assessment with the search path maps, they were improving both object knowledge and process knowledge, since the two types of knowledge are intertwined and should develop together (Chen & Paisley, 1985; Flavell, 1985).

Teacher self-assessment of own teaching and curriculum. Some of the teachers have found IMMEX to not only help them assess student thought patterns and progress, but also assess whether their own lessons and teaching have been effective:

It can be used two ways, it can show how well they are doing, and it can be used to see how well I am doing. Because if everybody is having trouble with the same concept, then it is probably me. So then I have to look at another way of teaching it.

There's a couple of things that I incorporate more into my thought process when I'm trying to do things as a teacher. One is I'm really a lot more concerned now about data. What kind of data do I use to make the decisions about what to keep or throw out in my curriculum. What kind of lesson planning to do based on what I want to accomplish.

For someone who's already got an established curriculum, this is great, because it gives them an idea of how well the kids are applying the curriculum they are using.

Assessment concerns and needs. Therefore it is apparent that the teachers interviewed on the whole found IMMEX to be a potentially significant tool. However, there appeared to be a need for further training in the use of search path maps and IMMEX problems as assessment tools, as well as strategies developed and shared which would enable the teachers to feel more comfortable in developing assessment strategies for themselves and their students. This is why most teachers felt very positive towards the idea, but few have actually implemented any type of assessment procedures. Once they gain more training and

experience with IMMEX and search path maps, the teachers will tend to rely more on IMMEX as both a teacher and student self-assessment tool.

I haven't used it as an assessment tool.

I am not comfortable yet using IMMEX as a full assessment.

(Interviewer: You don't feel comfortable with the search path maps?) Yeah, I just don't know enough.

Well, number one, I want to learn how to do the analysis, and I want to learn about the search path maps more and what you can analyze, what you can see out of them, what is it the teacher can do with this.

IMMEX Use for Problem Solving

One of the primary learning areas that teachers have focused on in integrating IMMEX into the classroom is that of developing problem-solving skills. In this complex world, the development of complex problem-solving skills is one of the more significant processes students can learn in school which will enable them to think, act, and work more effectively throughout their lives (Simon, 1993). Past research suggests that learning is an active process, requiring mental construction on the part of the learner (Scardamalia & Bereiter, 1986), and computer experiences can stimulate and promote the development of students' thinking processes (Paper, 1980; Pea & Kurland, 1984). That is why in the interview a number of the teachers placed importance on the students' ability to develop metacognitive and self-assessment skills, which will enable them to learn how to effectively solve complex problems. And the teachers who have experienced IMMEX have found the problems to be one of the better resources available for enhancing development of such skills. This is because the processes involved in problem solving must all be utilized if the students are to work through the IMMEX problems and come up with the correct solutions to these real-world problems, by applying the knowledge and skills they have learned in class.

I think it [IMMEX] is a totally transferable skill. Because I really don't know how to teach problem solving other than this way, going through, you know, step by step, thinking, taking all the pieces and solving the puzzle.

But being in science, of course, the nature of science is problem solving. So we have had a focus on solving problems through lab work in the past. In the research project that the students are

required to do also, the term project kind of thing. But IMMEX lends itself to more regular problem solving.

The teachers interviewed developed a number of strategies to help their students increase their abilities to solve problems. Often they share the processes and thought patterns utilized by various students, while pointing out various possible strategies that can be used to attack the problems. One of the teachers working with the students from lower socioeconomic environments, who might otherwise struggle, makes sure that she goes over the problems and strategies with these students to better enable them to improve their ability to attack and solve complex problems. Another strategy is to go over the problems, then periodically offer other IMMEX problems and continue to go over the problem-solving processes, hoping that eventually students will learn from their experiences and improve their skills. While doing so, several teachers stressed the importance of maintaining and reviewing notebooks, journals, and search path maps, so the students could learn from past experiences. One teacher even has the students review their search path maps and notes, then analyze their strategies and thought processes by actually writing the analysis on the search path map. They can then refer to this later when doing another IMMEX problem.

They have the one from November, they have the one from March, and then they'll have their search path maps. And they'll be able to go through them and write another journal piece for that. Just part of it is to have them learn to document, what it is they did and why they did it. Because next time when we do the problem, a problem, doesn't matter which one, they learn certain things like they have to document things better, so they can recreate them and that could get them back to the lab notebook.

Sometimes you have a student who sits down at the problem and they just keep cranking them out one after another, solving them with little effort. And sitting right next to them could be another student who gets totally frustrated. They just can't figure out how to put the information together to come up with a solution. And what they tend to learn is that they do have to accumulate information. They learn how to screen out what is important versus what is not important, or useful. And then build a case for making an informed pick as to what the solution to the problem is.

It's a two-part process for them. They have a study guide when they're working on the problems to take notes on. And then when they have completed a problem, I ask that they write down what their strategy was for solving the problem, as they saw it. Then we get the search path maps back, and I ask them to revisit what their strategy was after looking at what they actually didn't pick. That's why they write on the search path maps. I'm trying to get them to really think about their problem-solving strategies.

As the students go through problems, and discuss or go over what they have done with each IMMEX problem, the teachers note that their strategies tend to change. They learn what works and what does not work, and which strategies appear to be most effective in attacking problems successfully. And a number of the teachers have reviewed the students' work and noticed that change is occurring. This is especially true when the students are given IMMEX problems periodically throughout the year, so the teachers can track strategies and see if the students' problem-solving skills change.

I think if you look at the ones that the class did at the end of the year, compared to what we started out with, there's a much more focused attack on what is the problem. At the very beginning, they had a terrible time frame. "Well, what do they want me to do? What do they want me to do?"

What typically will happen is the first time through a problem, they will spend more time investigating the problem space. Looking around, spending a lot of time and money or points. Doing that, after they solve a first problem, and they do another case, the time to solution is greatly reduced. Because they are building some content. They've gone through the library, they've found out information, and they remember they don't have to revisit that.

So you introduce IMMEX right at the beginning. Couple of weeks later you do it again. And then all of a sudden you can start to see. Are we developing problem-solving skills that go beyond memorizing all of the menus in the problem that you are doing. Because kids do get better, you can see that in one problem set.

Some teachers also are using the structure of problem solving that they find in the IMMEX problems to develop more problem-solving exercises involving other learning activities, such as lab experiments, in their classrooms.

Another thing that has been helpful is that I've been thinking a lot of how to set up labs, so that there's more problem solving involved. And there's a couple of labs that I've changed this year in biology, so that kids do more of the problem solving. That they're not just following some directions, but they're doing more problem solving. And those are always the ones that the kids attack better. I think they're more engaged in solving those problems. They don't do a very good job necessarily all the time, but they're more engaged.

The only problem discussed by several teachers was that it would be more beneficial if the search path maps were more quickly made available. Many students learn much better if they get immediate feedback. And if the search path maps are not readily available, the teacher may have moved on to other content matter by the time they receive the maps, and they may lack the time to go over the problems, or feel that going back over old material may

disrupt the flow of learning. A solution for this appears in the suggestions section later in the report.

By the time I get them back, we're in the middle of something else. You know, even if it only takes them 2 or 3 days to get them back, and I think this time it was a week. The first time around it was a month. And the second problem it was only like a week. It was much faster. But by that week, by the end of that week, we had already jumped into something else. And so I didn't want to stop the kids' progress on the next subject in order to go backwards to do search path maps. It makes more sense for me to do that just before the next problem, so that what they learn from it is fresh in their mind, and they can apply it to the next problem. The only way to do that differently is if they can get instant feedback.

Thus one of the strongest points of IMMEX has been the fact that it enables students, with the help of their teachers, to develop problem-solving skills that can enhance their learning and future vocational endeavors. The development of these skills appears to be enhanced when one or more IMMEX problems are given frequently throughout the year. As the students apply the content knowledge and skills they have been acquiring, their skills in solving problems tend to increase over time, as they go over each problem, and discuss strategies, solutions, and their own progress. And if the teachers are able to have the tools and knowledge necessary to go over each problem with the students, discussing strategies and how the content can be applied to solve real-world problems, then there is a strong possibility that IMMEX can prove to be an effective tool in enhancing children's problem-solving skills.

IMMEX Use in Different Instructional Settings

Several issues arose in discussing the differences of working in collaborative or individualistic environments. Some teachers, who needed to have their students work in teams when doing IMMEX problems, often due to lack of computers, were concerned with the logistics of assessment and groups working on one computer. They felt that the search path maps and nature of evaluation required individual efforts. Others, though, acknowledged the value of collaborative learning, even with IMMEX. And one teacher in particular was adamantly against students working in anything but an individualistic environment. This is a significant issue, as there is currently a great debate amongst academicians and researchers regarding the relationship between collaborative and individual learning in relation to computer use.

Logistics in using IMMEX. Some of the teachers were not able to obtain enough computers for each student, so teams of two or even three students had to work at a given

computer. It was even more difficult when, as with the two academy teachers, students changed partners in each class, which made working with search path maps highly difficult. This resulted in a greater reliance on the study guides or notes, which both became more important tools in classes where IMMEX problems were done collaboratively. However, one teacher stated clearly that she could find no way to work with IMMEX except individually, as the whole idea of assessment using search path maps and problem solving for her could only be effectively accomplished with one student working individually on the IMMEX problem at a time. Another expressed positive feelings regarding collaboration, but felt that the IMMEX assessment process dictated that individual efforts were required.

That was very hard, because then it's hard to sort out who, whose thought process is really the active one.

When you sign on, which kid's ID number do you use? You can't track both of them. So that is a problem. It is a big problem, they always use the same ID number.

Yeah, so I have to have them one on one. And actually I find that with IMMEX, two to a station just really doesn't teach what you want to teach. Because one will dominate the other usually. And decide what we're going to do, and the other just becomes a passive watcher. So I don't find that IMMEX is very individual. It's not a collaborative event. And your search path map doesn't mean anything unless it's individual. So I use it just as individuals.

I like groups, but if I can find a way to do it individually.... If you are doing it in activity then groups are great, but if you are doing it in assessment and that is the direction I want to go in it at some point, then it has to be individual.

Collaboration as a positive activity. A few of the teachers did see the value of having the students work in groups, even with IMMEX problems. One found that it was a worthwhile strategy to team the high achievers with students on the lower end, who could increase their use of strategies, motivation, content knowledge, and problem-solving skills when working together. Several others just found that the use of group dynamics and interactions enabled the students to work together to solve the problems, while the sharing of strategies and thought processes also benefited the individuals involved.

We have the lower students and the smarter students, you know, the high end and the low end and the medium that are working together, and they don't work with their friends generally, which I think is again interesting. They are working with someone who has a strength they don't have and the conversations are, do you remember, do you remember, oh yeah. And they would talk about people they knew in this particular problem with High Life and they would talk about people they knew that had some of the same signs and symptoms and then kind of go, Oh yeah!

I think I prefer groups honestly, I think they need a lot of time in groups. And they talk about it, how they problem solve and maybe I would try it both ways, I am sure I would, but I think, I like the group dynamics. Because they are working together and then they are writing their notes down together, and it is nice that way.

They were talking to people they normally wouldn't talk to in some cases, and were listening also. So I think it was a positive experience for them.

Individualism preference. One teacher who worked primarily with AP students expressed quite strongly that learning and assessment, especially with IMMEX require that all work be done only on an individual basis. This teacher made efforts to let the class know that this was the expectation he had of them while in his class.

That's the idea. Sometimes they will try to collaborate, but I will remind them that they're not to collaborate.

[Regarding Internet use] It has the potential for being more flexible. And that would also enable less time being spent in the classroom. You can assign it as homework. The downside is kids will call up one another, and see how they're doing. Or collaborate, or sit together. So you don't have quite as much control. But there's a certain element of trust that you have to have.

Thus there appear to be mixed feelings over the value of using a pedagogy of collaboration versus individual learning. But most agree that the search path maps and nature of IMMEX, at least for purposes of assessment, favor individuals working alone on the problems. However, especially when working with students of varied levels and diverse backgrounds, many of the teachers find that it would be worthwhile to have them work in groups, as long as the assessment side of the IMMEX problems is not the focus.

Issues in IMMEX Integration

Student understanding level. Several issues were brought up by teachers regarding integration of IMMEX into the classroom. The first of these regards the need to ensure that the IMMEX problem chosen is at the level of the students in the given classroom. Some of the problems have been written for AP students, but have unknowingly been used by teachers in regular or ESL classes, which can affect the success and interest of the students. Teachers working with those who come from non-English speaking or lower socioeconomic environments need to be able to differentiate between problems and find those which can best meet the needs of their student population.

A lot of problems are pretty difficult, I think. Students just will not grasp or I haven't taught the material.... It would just really frustrate them. It is interesting that they are really high I think for like seventh or eighth grade and there are just a few, there is a few good ones that are in between also. But I think they are mainly high level. Graduate or college level.

The kids that I get, can't create something to put into IMMEX.... So they don't have the skills, they don't have the capacity to understand how it functions.

They cannot develop the content. And if they can't develop the content, they don't need IMMEX, and trying to explain IMMEX to them doesn't make any sense. Even though it is really easy to use, some of them never, you know, if I have kids that still can't find their program...

IMMEX problem sets. The other area of concern mentioned by many of the teachers was the breadth and availability of IMMEX problems. Several teachers thought it important that a concerted effort be made to ensure that IMMEX problems be made available or developed which would cover at least a majority of the areas of their curriculum. And others found that they not only needed some guidance, but also the time to go through the problems on their own. As one teacher noted, having the problems available is one thing, but the teachers need to sit down and go over each problem and assess the value of the problem for the given class and curriculum. But probably the major concern expressed was that the teachers did not have a full grasp of what IMMEX problems were available for their given content area, and of those about which they were aware, not enough time was available for them to review each problem and work them into the curriculum in a way that would ensure IMMEX integration. What is interesting is that one teacher had broken down and analyzed a number of the problems. This teacher, along with one other, presented some ideas regarding analysis and sharing of knowledge of the problems.

There are not that, I mean there are a lot of problems, but there are not that many that are going specifically for our type of students, you know, the ones that are health related. There are quite a few in science, and the science teacher uses them. This year, you know, we just weren't really organized in tracking which IMMEX problem we were using. We know when and we sort of knew which ones.

Every time there is an IMMEX problem added on, you know, so that we can see the new problems and kind of check them out and see if you would like to use it in the classroom, that would be helpful.

The other thing that is difficult is that I'm not as well versed with the problems as I need to be. Part of that is because they can give you descriptions of problems on paper, but it's never the same as if you're actually doing the problem. So I really need time to just sit down and do all the

problems. But I think that one thing that I would love to be able to do it there's going to be anything available this summer is to have some time to just go and sit, I don't care where it is, and try a bunch of problems.

How people have used the different problems, and problems that I haven't worked, or don't know as well. In each year, we have a whole batch of new problems. It takes a lot of time to sit down and spend several hours on each one of them to see if they are worthy of a place in your curriculum. If they fit, if they cover the things that you think they're going to cover. So that would really give an interchange with other teachers as to which problems they're using, where, and how.

Conclusion

It is apparent that most teachers interviewed have found IMMEX to be a valuable source for supplementing and enhancing content, bringing the real world into the classroom, and enabling students to develop their problem-solving skills. It also has value as an assessment tool, both for teachers and students, to help them develop metacognitive skills. But many still feel they could use more training and guidance in use of the search path maps, and in how to use IMMEX as an effective assessment tool. There is also a need to learn more about the availability and application of the various IMMEX problems, especially in relation to integration of the problems into the curriculum in an effective manner.

IMMEX Impact on Students and Teachers

According to the teachers interviewed, integration of IMMEX into the classroom has definitely impacted both teachers and students in several ways. It has affected their motivation regarding both learning and technology issues. It has often positively affected the students' problem-solving skills. It has even had the profound effect of allowing a student, whose ability had previously been questioned due to language deficiencies, to blossom in the classroom, and become recognized as having a complex brilliant mind despite struggling with standard tests. And the teachers seem to feel this is especially true for those marginal, low-achieving students, who have otherwise been struggling in class. Finally, some of the teachers have found that working with IMMEX has had an impact upon their own attitudes and skills.

Impact on Student Motivation

Teachers have found students to become quite involved and engaged in the learning process as they work on IMMEX problems. This is not only due to the interest of the

problem, but also the fact that the students are actively able to participate in the problem-solving process, since interacting with the problems requires active thinking and initiative on the part of those involved. That such participation enhances motivation and learning has also been indicated by many researchers who have studied child-computer interactions in constructivist environments (Brown, 1985; Campbell, 1984; Paper, 1980; Ritter, 1988; Sandhorltz, Ringstaff, & Dwyer, 1990). Other researchers suggest that computers are motivating to the extent that they increase challenge, control, and curiosity (Lepper & Chabay, 1985; Lepper & Malone, 1987). The rapid feedback provided by the computer can inform students when they have done something correctly, thus reinforcing a sense of competence that is strongly motivating (Deci & Ryan, 1992). Our interview data support the assertions made by past research. The teachers found that working on computers in a directed manner focused on solving problems became an enjoyable, engaging, and fun experience for many of the students. This is enhanced by the fact that the students were now able to apply the subject matter they had learned to issues and problems relevant to the real world. Some students otherwise disinterested in school seemed to be enjoying the experience. According to the teachers, students' behaviors improved as a result of working with IMMEX and actively engaging in the problems.

They're completely devoted. You could have probably dropped a bomb on the rest of the room, and not disturbed what they were doing. They are so intent when they work on IMMEX.

They are interacting with something. They're not passively sitting there listening to something. They're actively looking for things. They have the control to pick and choose what they want. They don't have to sit and wait for someone to tell them what pick.

They're making quite a bit of progress. They sat down with Aquarium Blues, which is chemistry. And for kids on the low end, putting chemistry in front of them, there's a psychological block. It's big stuff! And they just chugged right away at it. You could hear a pin drop. Except for the questions, "What's this?" "What's that?" And I said, look in the dictionary. And we saw some excitement with these kids at the end of the year.

Impact on Problem-Solving Skills

Though the development of problem-solving skills was discussed in detail in the previous section, it is still important to note the impact working with IMMEX problems has had on students. As the students worked with IMMEX problems over time, many showed noticeable improvement in their problem-solving skills because they were not only interacting among themselves, but also learning from their teachers.

I see it right then and there and then we have conversations about it and in talking with kids about a multitude of other things, that I can actually see them problem solve. And I am, sometimes I am like, that is why I keep you around. You are smart, you figured this out by yourself. And I actually now rely on a lot of kids to solve some problems for me.

So you introduce IMMEX right at the beginning. Couple of weeks later you do it again. And then all of a sudden you can start to see. Are we developing problem-solving skills that go beyond memorizing all of the menus in the problem that you are doing. Because kids do get better, you can see that in one problem set.

I think another person that has done well on the IMMEX problems this year is a girl... in sixth period. And she didn't do very well on the first one, she did a lot of guessing. She was in a group that did a lot of guessing. And she gets "As" in the class. Very conscientious worker. But problem solving is still from the first approach, is not very good. But when she was given a chance to analyze her search path maps, and compare them to what sort of an ideal would be, where you're trying out a lot of things, and then narrowing down. Her skills improved a lot. And her search path maps looked a lot better the second time.

Impact on Disadvantaged Students

One of the most significant findings by the teachers is that many of those students who had been struggling in the regular classroom were now able to show an improvement in their problem-solving skills. Teachers were able to point out examples of students who had struggled with regular classwork that seemed to blossom as a result of participation with IMMEX problems. Even those who were at risk and had a negative attitude toward school at times showed signs of improvement. Some teachers believed that working on IMMEX problems helped students learn to make logical connections and improve their organizational skills. Other teachers pointed out that the nonlinear and visual representation of information on the computer provided a different modality of learning which matched well with the learning style of some disadvantaged students.

She's not, her thoughts are not very organized. So she's the kind of person that, in solving a problem, would jump from one thing to the other without any logical rational train of thought. But when we did the second problems, the True Roots and Roots Quest ones, she was a lot better about taking this piece of information and then making a logical connection to the next piece of information. I think her search path maps improved a lot, and I also think that improved her attitude about doing the problems. Because... she felt more successful.

I have one student who kind of struggles with the curriculum and the reading, has difficulties reading. But [they] did very well, just getting on the computer, working on the computer, and

solving the problem, yes. That person loves to use computers and loves I think problem solving. But [he] just has a really difficult time in reading, like I have a lot of times with the students have to do homework and they take the textbook home and they read the textbook and that is just very difficult. But I think that all the different, you know, visual aids and things helped for them to solve the problem.

One interesting case has been a student who recently immigrated and could not communicate in English. But she had a strong intelligence and complex higher order thinking processes that were brought out through involvement with IMMEX. Instead of being dropped from advanced level courses, this student, through her achievement with IMMEX, was able to gain special recognition for her outstanding thinking skills. The amazing story of this student's success can best be told through the words of her teacher:

[She] has been chosen as the Howard Hughes Fellow to work at UCLA this summer, based on her IMMEX scores. She's one of my more outstanding students. She's AP biology. She's also AP calculus. And she's only a tenth grader. So she's an amazing young lady. But her English.... She may not score very high on the AP bio. She had a terrible time understanding the questions.... Her English teachers, and some of the other teachers didn't think she was particularly bright, because of her struggles with the language.... It takes her so long to read the question and understand it, she doesn't finish as fast as the other kids do. And so you wonder if she's mentally getting it. Well, then we looked at IMMEX, and it was, "Yes, she's getting it." It's just a language problem.

Impact on Teachers

Teachers found that using IMMEX in the classroom could affect them as well. They gained awareness and appreciation of computer applications that could improve their curriculum, while enhancing their students' skills and learning. At the same time, at least one mentioned that working with such a program, including analyzing, authoring, and integrating problems into the curriculum, increased his confidence as his own skills and abilities increased. Another teacher used her experience with IMMEX problems as a primary piece of evidence of her abilities when she applied for national certification.

Oh, I've learned a lot about computer use. I started out as a Mac user. Through IMMEX, I went over to the dark side of the PC world, and learned how to use all that, and learned various applications, and so forth. And of course authoring. So I guess my content knowledge has increased as I've researched problems.

Yeah, the National Boards. I'm working on becoming Nationally Board Certified. Yes. I've used IMMEX in two of my entries. The entry one, teaching a theme over time, I used Plate Tectonics and Earthquake Hunt was part of the assessment, even though this year it didn't work so hot

because of the earthquake, which is an interesting concept by itself. And I used it in assessment. It's one of the three assessments I evaluated.

Conclusion

Thus it is apparent that the IMMEX program has had a definite impact on both teachers and students. It has helped those students whose academic skills were limited to go beyond themselves and show improvement in their problem-solving skills. It helped those who were academically strong, but may have been unable to demonstrate their skills and thought processes due to language. It has helped to engage students in the learning process, especially as they are able to take the initiative and get actively involved in their own learning process. And it has helped to improve the situation for teachers, as they gain a new tool to help supplement their curriculum and enhance both students' problem-solving skills and content knowledge.

Issues in Implementing IMMEX

As they implement IMMEX in their classrooms, the teachers discussed a number of issues that they felt should be considered. The first of these involved whether or not the teachers would be able to access the technology necessary to use IMMEX with their students. Part of the concerns here were then alleviated with the expectation that eventually the IMMEX problems would become Web-based. In discussing the relation between IMMEX and the Internet, teachers expressed concerns regarding accessibility to the Web as well as the viability and ease of doing IMMEX problems on-line, though most had positive feelings regarding this possibility. A few teachers were concerned with both the pressure of other priorities and support from their administrations. Other teachers discussed further training and the possibilities of either themselves or even their students authoring IMMEX problems. Finally, several teachers mentioned the possibilities of making presentations and going out into the educational community to spread the word about the use of IMMEX as a viable additional tool for enhancing curriculum and building problem-solving skills.

Technology Access

While many of the teachers have concerns regarding accessibility to the computer, the situation appears to have improved considerably since fall 1999. However, as computers are added, more teachers become interested in using computers as educational resources, so as the supply grows, so does the demand. Therefore even with more computers the accessibility is still a concern for most teachers. While the teachers are pleased with the increased number

of computers, some of them are able to use IMMEX more often while others face the issue of competing with colleagues to gain access. One teacher mentioned that he had learned to rely more on the use of the laptops from the IMMEX support staff, which enabled him to do more problems than he otherwise could have done. Thus the teachers are learning how to cope with this issue.

We're getting more. We got a Digital High School grant, which is over a million dollars, and we are getting a lot of computers.

I would like to use it... ideally in a little different time sequencing, because sometimes there are certain content areas where there are IMMEX problems that I would like to use, but I don't have access to computers. So I either have to delay using it, or not use a problem. Because by the time I get it, we're on to something else. But generally, it hasn't been a huge problem. It would just be more convenient if I had computers on a ready availability.

The only difficulty is that the more people we train to do IMMEX, the fewer times I can get on the computers. And it used to be, in the first years, that I could have one whenever I wanted, because nobody else was using it.

I have got the opportunity to use the laptops for IMMEX and word processing and PowerPoint presentation that a couple of my classes made and it gave me the opportunity to use the laptops for IMMEX. So if I didn't have those, I probably wouldn't have done IMMEX this year. All the difference in the world has been made since we have those laptops. Since we have the laptops... there is now a way that we can say, okay, you can take this IMMEX technology and use it tomorrow.

Several teachers again mentioned the fact that most computers in the schools were Macs rather than PCs. However, with the availability of the laptops from IMMEX, and the increase in Web-based IMMEX problems, these concerns should soon be alleviated. Thus the concern regarding Macs will presumably diminish over time.

They are unwilling to make IMMEX for Macs. Most of the computers in LA Unified are Macs. They keep saying, run Soft Windows or Visual PC. I have an older machine now, but it was a new machine when I got it. I got Virtual PC on there and it is deadly, it is so slow, it is like running in slow motion. And that is useless. So running Virtual PC is not the answer. Converting it to Mac would be the answer.

We have pure Macs, because that's the industry standard for schools. But you know, all the science, all the science department people have Macs. We have three teachers with computers in their rooms. Mr. Covington has, like 20 computers in his room. He's a science teacher. They're all

Macs. So Macs are nice because they're user friendly and they sell all these cute little probes and things you can use.

Web-Based IMMEX Problems and the Internet

Although only one teacher had actually had his class do IMMEX problems over the Internet, a majority of those interviewed concurred that Web-based problems would alleviate most of the technological concerns, and open the door for the spread of IMMEX. It appears that most of the schools have either been wired for the Internet or are in the process of getting set up, so Web-based IMMEX problems are expected to become a viable alternative in the near future.

I understand that if we were on the Internet, it wouldn't matter if we were on the Mac or PC. We'd be able to download the problems from the Internet. They said they had several problems available on the Internet now, and it didn't matter if you were on a PC or a Mac to be able to download them off the Internet.

We also have the Internet access in the library, and that is on all those machines. Then students can access the Internet. And that we're seeing a great use of. It's very positive.

The teacher who tried out the Web-based IMMEX problem, Plasmids, had mixed results. The students were able to work on their own time, and enjoyed the process, but many became frustrated because the problems had been developed on Netscape and most of them were using Internet Explorer. Unfortunately there was an incompatibility bug when using Explorer, but the teacher believed that this problem was in the process of being fixed.

Well, the IMMEX software lab is trying to put all of the usable problems on their Web site. And the earlier problems seem to work best using Netscape. It's a kind of browser. And most of my students are using Internet Explorer. Well, there were some frustrations. Because using Internet Explorer, they weren't able to access some of the menu items in the problem. But apparently they're reconfiguring more current problems to work on both platforms.

Out of 32 attempts, seven solved it. And [counting] 26 of the 32 completed the problem. So some weren't able to complete the problem. Because of difficulties gaining access to certain menu items.

The attitudes of the teachers were, on the whole, very positive toward Web-based IMMEX problems. It is just a matter of getting connected, then getting the proper training to ensure that they are able to effectively implement the Internet version of IMMEX.

I really like the Web-based version. I didn't use it in class, but I did a workshop for other teachers and we used it there, so. But I like seeing it on the Web and there is some things about the Web version that I like and that are different. I think actually the Web version will be the way to go.

Well, it would be nice to have more problems Web-based and workable for all students on any browser. That would enable me to use less class time, and still have them doing the problem solving. I would definitely use it more often. And different, instead of regular time periods, and I'd run two or three problems over a week. Or two times, instead of having one problem this month, and another problem next month.

I will after these workshops, because I will know a little bit more about Web-based software and what the capabilities for the Web are. Because I think that is where it is gonna be at. Previously, you would have to give them a CD, they would have to go through the trouble of downloading it off the CD, making shortcuts, and a lot of hassle. So I think without knowing enough about it I think that is the way it is. And I think there needs to be a way on the Web site that they could download directly to their machine, so they can take it with them when they are off-line a version, let's say on Plasmids, that works on the Web, there should be a platform where they can download a playable version on their home machine.

Implementation Versus Other Priorities

In the current environment focusing on standardized testing and school improvement, the teachers have found other priorities often affecting their implementation of IMMEX. Administrators often require the development of curriculum standards and the preparation for standardized tests to take priority over all other educational endeavors, including the implementation of a problem-solving program like IMMEX. Fortunately, as discussed in the integration section, the teachers are finding IMMEX problems to enhance student achievement, while helping themselves and their students better meet curriculum standards.

And then we have the SAT 9, so you know, we've been geared up for that since January. Because we were under a lot of pressure from parents and from the school district and from the principal to raise the scores. I mean everything at this year is driven by the SAT 9's, everything.

Focus on learning for the accreditation. And then we are working on the Digital grant right now, so everybody at the school is just like we're stretched really thin and I keep saying that I would like to spent part of a staff development day, to teach interested teachers in what this problem is about, and I would like to day a staff presentation, take 15-20 minutes of a staff meeting every Monday morning. I don't get that kind of support from the principal.

Authoring Problems

Many of the teachers expressed an interest in getting involved with the authoring of IMMEX problems, especially if given the time and proper training. Teachers realized that authoring is a complex and time-consuming activity, but often felt that their involvement would result in a greater depth and breadth of problems that they could integrate into their curriculum. One teacher expressed a concern for setting up the right groups and training to author IMMEX programs, which stemmed from her challenging experiences in her last authoring attempt. But even she demonstrated a desire to continue to be involved in the authoring process. Others found past involvement increased their confidence and interest in authoring more problems.

I need to devote more time to writing problems. I'd love to be able to write the problems for my class. Or, take a problem that's already there, and maybe doctor it to make it more in line with my classroom curriculum. And I just, I simply don't have the time to do that.

I'd actually like to author another problem down the road, but I have to feel confident with whom I was working with, and I don't want to be let down.

Several teachers mentioned challenging experiences in their authoring process that they felt needed to be addressed. Several felt that the teams created to author problems should come from the same academic disciplines. This would ensure development of IMMEX problems that they could integrate into their curriculum. One teacher found that she was teamed with teachers of the same academy, but with entirely different content knowledge and interests. The result was development of an IMMEX problem that could not be used by any of the participants. Another concern that one teacher expressed is that when the teachers work in authoring teams, all have to be committed, need to share what they are doing, and stay throughout the process. Another teacher felt that their group was abandoned, since the support member working with the group had them completely change what they had spent a good deal of time preparing. The feeling here is that the assigned group, including support, need to work together until the authoring process is completed.

Because then you're more likely to use the problem that you author in your class, if you're focusing on your content. And since none of us, or since that, you know, really we were focusing on one person's content in each of those groups. In another teacher's situation, they were focusing on her content, because that's what the whole academy centers on.

I am interested in authoring. But one thing we learned as a team, that unless everyone has the same commitment level, it is very difficult. Because we had a couple who don't have the same

commitment level and it's created problems for the two of us who have a strong commitment level. So when half of the team poops out, it is very challenging.

Thus a significant point is that the problems should either be authored by persons with the proper content knowledge or background, or those without full knowledge make the time and commitment to learn all that is necessary to effectively author problems that can be integrated into the classroom.

Well, because when we did last summer, it was for the academies, and each is a thematic academy. So you had academy teachers working together. So if you wanted to have one that was just science-based, or just one that was history, or math-based, then it would make more sense to group them by disciplines.

I am kind of open for anything, because actually if I was working in an area that I didn't know that much about, it would make me learn something, and make me research stuff. So you know, I am open to that as well.

Another point made by some teachers is that, while some of the IMMEX problems have had a few bugs or glitches, there was good communication between those using the problems and those who authored them. The result was usually that there was a concerted and ongoing effort to clean up any problems with the IMMEX programs. There had also been attempts to continue to update programs and add clones, so that IMMEX could better meet curriculum requirements. In addition, a few of the teachers are already planning ahead to author specific IMMEX programs.

We have authored that program, High Life, and she was going to present that to people in Seattle. So, she needed, we needed to work really hard on making that better, that program, that problem better. Because there were a lot of glitches in it. So we got together and worked on that problem for a while, for a couple of weeks, and helped make it better. Because we only had three clones to it and we added two more, so that is what we have been working on in IMMEX.

Well, I'm currently writing another one involving the digestive system, that is a huge problem. It's taking a while. I hope to finish it this summer, and use it next year in my physiology class.

There was only one teacher who felt that most teachers are not properly equipped with the knowledge and tools to effectively author IMMEX problems. But this teacher did feel that teachers could work with the programmers and developers as consultants who share their knowledge of their content area and ensure that the programs developed will be able to be integrated into the curriculum.

Teachers are not necessarily good problem solvers and I think they found out certainly part of what people do is limited by what they can do on the computer. You are not gonna put graphics in if you don't know how to do graphics.

Student Authoring

Several teachers have also planned to get their students involved in the authoring process. This should enhance the students' understanding of the content area, while giving them valuable technological tools and skills, so they can further apply what they have learned. Students also come from the same age and technologically literate group of persons who will be actually solving the IMMEX problems. So with proper guidance and support, they might be able to develop problems which are in line with the skills and interests of their peers.

And it is nice to have students be able to see different pieces of technology and it would be really nice to have the students, you know, if I had time to do that, it would be really fun to take one group of students and have them come up with an IMMEX problem, and the items and do the paper prototyping. And have them understand and using technology to create a problem. I mean to me that would be a very exciting idea.

And then the other student you met today, is within the same program, but she is actually gonna come with us in the summer, and try to author one. So she knows about technology now she went through the Howard Hughes program, and worked in the lab with me all summer. So she knows about the technology and knows Windows and stuff, She doesn't necessarily know the IMMEX environment yet, but for an intelligent person it doesn't take that long to learn it.

Presenting and Sharing IMMEX With Others

Some of the teachers also have found it important to spread the word about the value of IMMEX as an effective problem-solving tool that can enhance student understanding and application of what they are learning in school. Several of the teachers have given presentations at educational and science conferences, with positive results. As a mentor, one teacher has even introduced IMMEX problems to all of her teachers in training. The level of interest in IMMEX is quite high. The only thing recommended is that the IMMEX support group then have CDs or Internet IMMEX problems available as the demand increases.

I think that that conference really was a good idea. I think that for IMMEX if you want to sell the program, because it is a free program, you need to kind of find where the conferences are which teachers are going to and where a whole bunch of teachers are getting together and going to little different mini-sessions. And then just sell it and have teachers try to sell it to other teachers. I

think it is important that teachers try to sell it to other teachers, because teachers know what problems come up with kids and classroom management and all of that, so. I had a really fun time with it, I think it was a really positive experience. But the teachers, they are really interested in it.

Everybody is very interested in it, but when you just go in and you talk about it for 15 or 20 minutes and everyone says yes we would like to do this, how can I get this, how can I get that. The follow-up is involved, because I have heard from some people at the national conference in Seattle that there was this one teacher and her administrator, who were trying to contact them, without success. Hopefully that has been resolved. I think it's really a great program and I want to tell like the whole world.

Oh, it's so exciting! I want to take it to the Geological Society of America. I've given papers there before. And do a poster session. I didn't have time the last couple of years. But this year it's time to put in the abstracts, and show that. Because there's a LOT of geological applications to this. Geology is all thinking process. If you write half the time, you're good. Because we're working with all sciences integrated. And it's what beginning geologists have a hard time doing.

Conclusion

The teachers continue to have some concerns regarding the implementation of IMMEX, while still remaining enthusiastic about the future. Though the computers are now being made available in most schools, the demand by other teachers is even growing at a greater rate, resulting in continued scheduling problems. But much of this, along with concerns regarding Macs versus PCs, will be alleviated with the implementation of Web-based IMMEX programs. Teachers are enthusiastic about the use of IMMEX on the Internet, but some schools still need to be wired and more problems need to be made accessible on the Web. Teachers are concerned with the fact that IMMEX has a low priority in schools which focus on developing and meeting curriculum standards and preparing students to do well on standardized tests. Further research needs to be conducted to see if IMMEX programs also enhance the skills required to pass standardized tests. Teachers also have great interest in authoring, but only if they are given the time, support, and training necessary, and if authoring is done, or at least reviewed by those with adequate content knowledge. Finally, there is a movement to spread the word about the use of IMMEX as a significant tool for supplementing and enhancing classroom learning on the part of those exposed to this problem-solving tool.

Recommendations for Improving IMMEX

As they discussed the integration of IMMEX problems into their classes, teachers at times interjected suggestions which could enhance the integration, implementation, and growth of IMMEX. The following suggestions were given.

More Information about the Problem Sets

While many teachers were concerned that they did not have a grasp of what IMMEX problems were currently available and which they might be able to use to supplement their content, one teacher recommended a summary and classification of all the problems, either available on a CD or on the Internet. Another suggested greater interactions between teachers, with perhaps a concerted, planned effort for those in given content areas to analyze and share information about various IMMEX problems that might fit into their curriculum.

There were problem summaries, but it was a summary of all the problems. It is all binders of IMMEX. I have workbooks on how to do IMMEX stuff. And if that was available, then somebody could go through there and as they were developing the curriculum. So that would be good. Even if it was published on the Web. If you have a password and so forth, so that you were trained, you could download that.... That is a tremendous idea. So you put in your IMMEX password and so forth and it says that you have been trained and so forth, and you can download this one and you sign that acceptable use policy that we all have to sign on. And then you can get it, and it is in this content and I need it tomorrow, so I can download it tonight and have it tomorrow. I don't have to call and say, well, can you send a CD.

How people have used the different problems, and problems that I haven't worked, or don't know as well. In each year, we have a whole batch of new problems. It takes a lot of time to sit down and spend several hours on each one of them to see if they are worthy of a place in your curriculum. If they fit, if they cover the things that you think they're going to cover. So that would really give an interchange with other teachers as to which problems they're using, where, and how.

Improving the Design of Problems

Several enhancements to the process of solving IMMEX problems were suggested by teachers. One recommended that the problems require students to go away from the computer and become involved in supplementary activities and tools, like conducting experiments or looking up information in other resources, which would increase the students' research and problem-solving skills. Several teachers suggested that IMMEX problems actually get integrated into lesson plans and textbooks, so that as one goes through the curriculum, the

IMMEX problems appear as supplemental materials. Another teacher recommended that the IMMEX interface itself be made more interactive and interesting for the students. Finally, teachers hope that they can download, organize, and collect search path maps and data, which would make it easier for them to conduct analysis and give back more timely feedback to the students.

You know what would improve it I think. I was talking to someone about this actually a couple of days ago. And then if you could do IMMEX and say like it is a chemistry problem and you have to find out density of silver and the density of copper. Instead of going to a menu item and finding the density of copper, that it would say, okay, now go away and figure out the density of copper in your lab. And you actually do it and calculate what that number is and then go back to the computer and solve the problem. So kind of link the computer to the lab. I think that would be really interesting.

What I think that they need to do is what the publishers do. In the beginning of the teacher's book there is a whole description of how to use the books that you have. And I think that if they had curricular areas, that they could package it with a book and a CD and say here, you know, you are gonna teach this, you are gonna teach this, teach this, and this, and these sets of problems go with this and whatever and that would be the way to probably get a little more, I mean, there are a lot of teachers follow it.

I think it really has to be exciting for these kids. I find it more and more difficult to get them, you know. It used to be whatever you did on the computer was great. Now you are competing with all of these explosions, sounds effects. I think it would really make the problems more exciting if they were in something like Hyperstudio which would allow you to randomly go to different places and you build a trail of where you went; instead of the pull down menu you would have selections.

Disseminating IMMEX to More Teachers

One teacher felt that teachers well versed in IMMEX could use it as a tool to teach new teachers they are mentoring, giving the mentees an additional, valuable teaching resource to add to their repertoire of materials, as well as spreading the use and awareness of this problem-solving tool. Another teacher recommended that IMMEX be introduced to new teachers through teacher education and professional development programs. This teacher also stated the effectiveness of using teachers to sell such a program as IMMEX to other teachers, since they speak the same language.

For someone who's already got an established curriculum, this is great, because it gives them an idea of how well the kids are applying the curriculum they are using. For someone who doesn't

have a curriculum, this, just doing this fresh, it gives them some focal points.... So I think it would be one of those things that would be nice for a new teacher to be able to draw upon. Have teachers try to sell it to other teachers. I think it is important that teachers try to sell it to other teachers, because teachers know what problems come up with kids and classroom management.

Conclusion

By interviewing teachers, we found that they used IMMEX to supplement their curriculum because IMMEX could fit well with the curriculum standards, the IMMEX problems were complex and interesting enough to challenge students and increase their motivation, the students were required to actively integrate information and materials, and the student could better understand and retain the content knowledge when working on IMMEX. Teachers also pointed out that becoming involved with IMMEX problems not only enabled students to apply what they had learned in class, but also increased their appreciation of the importance and relevance of the subject matter. The students could see that what they were learning would prove to give them skills which would be beneficial to their lives beyond the classroom.

Another major finding from the interviews was that with the development of search path maps, IMMEX had become a potential source for both teacher assessment of students and the students' development of self-assessment. Teachers found IMMEX to be helpful not only in assessing certain abilities such as problem-solving skills or creativity that may not be recognized through traditional methods of evaluation, but also in evaluating the real abilities of those students who were lacking in English skills or who were from disadvantaged backgrounds.

Our data supported the claim that the IMMEX program had a positive impact on both teachers and students. It helped to engage students in the learning process, especially as they were able to take the initiative and get actively involved in their own learning process. It helped to improve the situation for teachers, as they gained a new tool to supplement their curriculum and enhance both students' problem-solving skills and content knowledge. However, the teachers continued to have some concerns regarding the implementation of IMMEX, including the increasing demand for computer use which could result in scheduling problems, the low priority of IMMEX in schools which focus on developing and meeting curriculum standards, and the lack of time, support, and training necessary for teachers to get further involved with IMMEX.

To conclude, our evaluation findings have offered insight into how teachers use IMMEX software, what kind of barriers they encounter during IMMEX integration, and how

IMMEX has impacted teaching and learning. Based on our data, we suggest that future studies on IMMEX focus on how teachers and students use IMMEX on the Internet, how IMMEX can be effectively used for assessment, especially for ESL students, and what kind of experiences students gain by authoring IMMEX problem sets. We believe that research results from investigations in these new areas of IMMEX application can contribute significantly to the field of educational technology.

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APPENDIX A

Interview Protocol

Interview protocol Year 2-Post

In this interview we would like to focus on the use of IMMEX in last school year.

We are interested in changes that might have occurred since our last interview.

We do hope we won't have too many repetitions for you. If we do, then we need some more clarifications on that point.

| NO | QUESTION |
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| 1. | Discuss any changes in technology in the last year and how it affects you (e.g. access to computers). <ul style="list-style-type: none"> • Any other consequences? |
| 2. | How often have you used IMMEX (since our last interview in November 1999)? <ul style="list-style-type: none"> • Which problem sets have you used? • Do you have comments on the problem sets you used (positives, negatives, suggestions). • Would you have liked to use IMMEX more/less. |
| 3. | Given the problem sets you used, can you describe how you used one of those problem sets in your curriculum this year? <ul style="list-style-type: none"> • Teaching content or problem solving. • Assessment/grading/instruction. • Search path maps. • Assignments (how were they used in the process, what did you do with them, grades, feedback). |
| 4. | If you think about using those problem sets, what has been particularly difficult in last year's IMMEX implementation. <ul style="list-style-type: none"> • Can you give any examples? • Please give an example of something you would recommend? |
| 5. | Has IMMEX affected you personally? <ul style="list-style-type: none"> • Professional. • Teaching practices • If so, how? |
| 6. | Can you give an example of a student who did well on IMMEX this year? |
| 7. | Can you give an example of a student who is helped by IMMEX in the last year? |
| 8. | Suppose you could have regular meetings with other teachers at your school, what would you expect from those meetings? |
| 9. | Are you planning to use IMMEX next year? <ul style="list-style-type: none"> • Why, why not? • How? Any changes from this year? • Can you give examples? |
| 10. | Do you have any more insights on changes that could improve IMMEX? |

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| 11. | Do you need further training? <ul style="list-style-type: none">• If so, what kind of training and why?• Suggestions to improve the training? |
| 12. | Do you have any plans for authoring next year? <ul style="list-style-type: none">• Did you author this year? Experiences? Suggestions? |