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E-pals to Enhance Mechanics Learning*

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The E-pal Program linked undergraduate Kenyan students with practicing engineers, researchers, and other technical North American professionals in an e-mail 'pen pal' dialogue for the duration of an introductory fluid mechanics course. The Program aimed to counteract the dearth of resources at the Kenyan university by utilizing the Internet to facilitate the central three goals of the program: (1) to demonstrate to students applications of taught concepts and material, (2) to expose students to the range of sub-disciplines, careers, and engineering problems within fluid mechanics, and (3) to promote the use by students of the Internet in an environment where its value had not previously been demonstrated. The Program was found to be popular with student and practicing engineer participants and highly successful in achieving its goals. This paper gives an overview of the Program and its context within the Kenyan academic environment, delineates its successes and lessons learned, and discusses pedagogical value and applicability to other courses and situations with recommendations for implementation.

INTRODUCTION

THE E-PAL PROGRAM was initiated at Kenyatta University, primarily due to the lack of physical resources available to assist students in making intuitive connections between theory and engineering practice. Second-year fluid mechanics students were paired with North American professionals (PE-pals) who use the fundamentals of fluid mechanics in their daily work. The relationships lasted the duration of a 10-week term (late September to early December, 2001). Students submitted memos every two weeks summarizing their communications and addressing assignment questions posed by the instructor. The Program culminated with in-class student presentations in which each student gave an overview of their relationship and an assessment of the E-pal Program itself.

CONTEXT

Kenyatta University (KU), one of six public universities in Kenya, is located approximately 10 km north of the capital, Nairobi. There are 7474 students (2000/2001 academic year) registered at Kenyatta, 120 of whom are pursuing undergraduate or graduate degrees in Appropriate Technology in the Faculty of Science. Tuition is 16,000 Kenyan Shillings (KSh) (~$200 US$) per student per academic year. Including room and board a student typically pays at least 41,000 KSh (US$515) per year. Meeting these costs is a struggle for most students in a country where 78 percent of the country's population lives on less than $2 per day [1].

Students and faculty at KU have limited resources available to them. Textbooks are unaffordable for purchase; libraries are poorly stocked, with useful books often checked out for instruction by lecturers. Few laboratory facilities exist and those that do suffer from a shortage of equipment and experimental resources. There are no teaching assistants or allocated class budgets. Although the Appropriate Technology Centre (ATC) owns an overhead projector, the classroom assigned for this course did not have electricity. The students did, however, have access to computer and Internet facilities through official campus clusters where they were allocated two hours per week (in a block). They also had access to an on-campus Internet café that charged 100 KSh (US$1.25) per hour. Estimates from 1999 suggest that there were approximately 45,000 Internet users in Kenya which increased to 500,000 in 2002, supported by 5 Internet service providers [2].

The E-pal Program was initiated in Fluid Mechanics I, the first of two courses in a Fluid Mechanics series required for Appropriate Technology students. Students typically take Fluids I at the start of their second year, with the second part taken their third year of a four-year undergraduate program. The course material, dictated by university administration, includes fluid statics, an overview of kinematics, and an introduction to fluid dynamics. Due to the lack of resources and lecturer time constraints, this course had traditionally been taught purely verbally with few physical classroom demonstrations and little interaction between students and instructor. The general pedagogical approach at the university could be labeled 'type one teaching', which Peters and Armstrong characterize as 'the teacher as authority . . . and learners as nearly empty vessels' [3]. Student assignments stay in the 'knowledge bracket' of Bloom's Taxonomy [4]; assignments and testing focus on the recall of information with an emphasis on fluid mechanics theory and mathematics.

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The E-pal Program was developed by a visiting lecturer to ATC who was assigned to teach the fluid mechanics course. Course instruction remained primarily verbal, but was aided by the use of a chalkboard, simple demonstrations, short small-group brainstorms ('group explorations'), and a two-class 'water bottle-rocket laboratory'. Emphasis was placed on promoting practical and intuitive engineering skills. Supporting material was provided in the form of paper handouts and notes.

GOALS OF THE E-PAL PROGRAM

E-pal Program (henceforth referred to as 'the Program') goals were based on the university's required course topics, resources available to students, and input from engineers educated and/or presently practicing in Kenya. The first three goals aimed to address course and student needs, while the last four were incorporated with the evolution of the Program's design, development and implementation.

Mechanics-related goals

The mechanics-related goals focused on student learning and comprehension. They sought to supplement the course material without requiring access to equipment or textbooks.

1. *Demonstrate applications of taught concepts and material.*
2. *Expose students to the broad range of sub-disciplines, careers, and engineering problems within fluid mechanics.*

Professional goals

The third goal specifically aimed to 'get students online' as one-third of the Fluids I students did not have e-mail accounts at the start of the course. Of the students with e-mail accounts prior to the course, only two checked their e-mail at least once a week. Almost all of the other students with accounts checked e-mail less than once every two weeks or 'rarely'.

3. *To encourage Internet proficiency and demonstrate its value.* The instructor believed Internet competency and experience would lead to the recognition and utilization of online information resources, which offer the potential of providing much needed supplementary material.

Enhancement goals

The four 'late-addition' goals focused on providing students and PE-pals with information that enhanced their understanding of other cultures, engineering as a profession, and the multitude of paths to different satisfying careers.

4. *Provide North American PE-pals with an alternative perspective of engineering and engineering education*. To avoid unbalanced personal relationships, the Program structured the E-pal correspondences as information exchanges. It was hoped that PE-pals would be able to enhance their understanding of technical careers in less industrialized environments.
5. *Provide mentorship to students at a distance*. The advantages of using foreign PE-pals were that students were almost entirely dependent on the Internet for communication, the relationship was more easily terminated at the conclusion of the course, and a broader range of expertise than that available in Kenya could be presented.
6. *Prepare students for professional life after university*. In spite of the number of local engineering graduates, a large number of practicing engineers in Kenya are expatriates or Kenyans who received their engineering degrees at foreign universities. When queried about this, local engineering managers claimed that foreign-trained engineers were more prepared technically and professionally than their locally-trained counterparts.
7. *Foster a global engineering community*. The final goal sought to build personal relationships as a means of encouraging cross-pollination and international linkages where ideas and technical know-how could be shared.

IMPLEMENTATION

Design and implementation of the Program followed as much as possible from the program goals.

Recruitment and matching

The instructor selectively recruited PE-pals through e-mail solicitation focusing on professionals working in fluid mechanics. As PE-pal slots were oversubscribed, selection aimed for a well-balanced mix of gender, ages (although tending toward young professionals), races, and fields of expertise within fluid mechanics. Preference was given to those originally from Kenya (and similar economically-bracketed countries), their ability to commit time, interest in the program, and the diversity he or she brought collectively to the group.

Students and PE-pals were matched using information they provided about themselves. Students completed a survey the first day of class and then submitted a statement by e-mail to the instructor (compelling students to obtain e-mail accounts early in the course). During recruitment PE-pals submitted short autobiographies to the instructor by e-mail including their interests and work. When pairs were assigned, only minimal information was given to participants about their E-pal partners as the instructor intended introductions to serve as an icebreaker.

Student and PE-pal demographics

Student participants' ages ranged from 20 to 25 years, with an average age of 21.7 years. They

were geographically and ethnically diverse, and representative of the major tribal groups of Kenya.

The male to female ratio for PE-pals was similar to that of the students, except there was one more woman (five women and twelve men). The PE-pals' ages ranged from 23 to 55 years, with an average age of 32.5 years. The highest level of post-secondary education was distributed: two bachelors degrees, eight masters degrees, two with multi-masters degrees, and five doctoral degrees. All but three PE-pals were geographically located in Northern California in the United States. Five of the seventeen PE-pals were non-American by birth. Occupationally, seven were engaged in research, seven were engineering professionals, while the remaining three held jobs pertaining to both. (Seven were graduate students.) Areas of specialty included: aeronautics, astronautics, environmental sciences, thermal sciences, product design and development, medicine, viniculture, bioengineering, and microfluidics. Because the ATC emphasizes water technology and other environmental flows, the number of environmental engineers recruited was disproportionately high (5 of 17).

Matching and pair demographics

One-third of students were given 'topical' matches. That is, based on students' stated interests, it was possible to pair them with a PE-pal in a closely related occupation. One student, for example, wrote in his statement that he hoped to be a fighter pilot; this student was paired with a mechanical engineer who flew F/A-18 aircraft in the United States Navy. Matches like this, however, were not possible for all pairs as PE-pals were recruited before the commencement of the course. As expected, not all students were familiar with the range of sub-disciplines before having taken the course.

The gender demographics of the pairs are shown in Table 1.

GRADING SCHEME AND ASSIGNMENTS

Students were instructed to assume the role of consultants hired to learn as much about and from their PE-pal as possible, comment on how technical information related to engineering concepts covered in class, and communicate it in a professional manner. The 'consultancy model' aimed to strengthen professional skills required for frequent job hunting; many of the more highly paid jobs in Nairobi are foreign-funded with one- to two-year contracts.

Table 1. Genders of matched E-pal pairs.

Student	PE-pal	Pairs
Male	Male	11
Male	Female	2
Female	Male	1
Female	Female	3

The E-pal Program constituted 10 percent of the student's final course grade. (This percent was the highest possible given university norms and regulations.) This grade was equally divided between bi-weekly memos and the final in-class presentation. These forms of assignments aimed to promote and emphasize 'communication between engineers', bringing excitement back to a more 'traditional' engineering education, which tends to focus on engineering analysis [5]. As the educational value of the E-pal program was not immediately evident to many students accustomed to examinations and lectures focusing on information, formal grading was believed to be necessary to encourage motivation.

Memos

Memos were assigned and due every two weeks. This spacing was set to accommodate anticipated delays in Internet access and communication, and the submission of weekly problem sets. (The only restriction of the E-pal Program was that homework problems were not to be discussed.) E-pal assignments (introductory e-mail and four memos) were due over the course of the semester; the topics of each and the corresponding goals are shown in Table 2.

The topics provided by the assignments were intended to act as seeds for discussion between E-pals and PE-pals. To encourage the exchange of additional correspondence topics, grading was not based on detailed explanation of all topics.

While it was not required that memos be typed (none were), it was expected that students follow an appropriate format and not exceed 1–2 pages in length. A sample memo was distributed after the second class explaining format, notation and typical purpose.

Final presentations

The E-pal Program concluded with in-class oral presentations on the last day of class (see Table 2). The presentation format was selected to meet several objectives [6]:

1. to share knowledge, experiences, and information regarding the students' correspondences;
2. to encourage public speaking and presentation skills while giving students a non-analytical means to demonstrate gained knowledge;
3. to conclude the program in a celebratory, rather than competitive manner.

The final presentation was a key element in five of the seven goals of the Program.

The presentations were five minutes each with an additional minute for questions. As it was possible to secure a classroom with electricity, each student was allowed 2–3 overhead projector slides. (This format of giving presentations is common for graduate students and faculty at

Table 2. E-pal assignment overview and goal alignment (see Goals section for description of goals).

Assign. No.	Topic/Title	Description	E-pal Program Goals						
			1	2	3	4	5	6	7
0	E-mail Check-in	Students were to send the instructor a short e-mail with full name, university registration number, e-mail address, and how they hoped to apply what they would learn in Fluid Mechanics I.			✓			✓	
1	Who is your E-pal?	In memo-format, students were to provide basic information about themselves and what they had learned about their PE-pal. Suggestions included age, occupation, hometown, place of current residence, hobbies, and connection to fluid mechanics.	✓	✓			✓	✓	✓
2	Fluids Work and Research	Assignment 2 had three parts:							
		(A) *Fluids specific information*: Students were requested to investigate the fluid(s) which pertains to their PE-pal's work or research, the most important properties of the fluids, and some common assumptions PE-pals make in their analyses.	✓	✓					
		(B) *Personal/Professional information*: Students were encouraged to ask their PE-pals about their work environment: How many years had the PE-pal been at their current place of work? What was a 'typical' day at work?					✓	✓	
		(C) *Reflection of new knowledge:* Extra questions were assigned for the student to consider, such as: Into which area of fluid mechanics did your PE-pal's work fit? Were you surprised by your PE-pal's 'typical' day? Students were also encouraged to request digital photos from their PE-pals.			✓			✓	
3	Application of Fluids Theory and Work	Similar to the previous assignment, this assignment also had three parts:							
		(A) *Fluids specific information*: What equations or principles (if any) does your PE-pal use most often at work? What instruments for testing or measurement does she use?	✓	✓					
		(B) *Personal/Professional information*: What are your PE-pal's thoughts on how university compares to work? What does your PE-pal wish he had learned earlier? What are the best and worst aspects of his job? Has he ever been to Kenya?				✓	✓	✓	✓
		(C) *Reflection of new knowledge:* Did the student feel that her PE-pal's insight into work after university is applicable to Kenya and her experiences?						✓	
4	Design Your Own Assignment	The intention of this assignment was to encourage students to ask follow-up or new questions based on previous dialogues. An in-class brainstorm provided additional topics for discussion with their PE-pals.				✓		✓	✓
5	Overview and Evaluation of the E-pal Program	FINAL PRESENTATION: The content of presentation was left open, but students were requested to include an overview of their PE-pals, what information they had learned from each other, and an honest evaluation of the Program. (See 'Final Presentations' in 'Grading Scheme and Assignments' for more information.)	✓	✓	✓			✓	✓

Kenyatta and in local industry.) To accommodate hand-written slides, blank paper was distributed for slide preparation. Submitted slides were color-copied onto transparencies and returned to the students before the final presentations. As most students had not used an overhead projector before, approximately half of the class took advantage of the 'projector practices' during office hours leading up to the presentations.

Three engineers from local industries were

invited as guest graders to give feedback to each student. In addition to introducing students to practicing local engineers, the presence of the professionals increased the formality and professionalism of the presentations.

PE-pal support

The bulk of the informational support provided to the PE-pals occurred in the first few weeks of the semester; this was followed by bi-weekly updates written by the instructor. Student photos were taken the first day of class; once class numbers were confirmed and E-pals matched, copies of the student photo and information sheet were mailed by post to the PE-pal. The instructor also e-mailed PE-pals a lengthy overview of Kenya that focused on economic, social, and academic conditions. The later bi-weekly updates summarized the in-class activities, addressed evolving administrative issues (transmission of large electronic files, for example) and gave reminders of student requests.

Grading

The goal of the grading was to keep students interested and motivated. The instructor responded to memos with comments and questions in the margin. For example, one student was encouraged through this written feedback to ask his PE-pal who had finished his Ph.D. at the age of 23 years if this was usual.

At the final presentations, special guests, peers, and the instructor each contributed one-third to comprise the presentation grade. They evaluated the verbal and visual quality, clarity, and professionalism of the speaker and accompanying materials. Students were provided with the grading sheet to be used in advance of their slide preparation.

Program assessment

Assessment of the E-pal Program was accomplished through several means:

1. PE-pals were encouraged to make comments to the instructor throughout the semester.
2. Students were asked to give an honest assessment of the program as part of their final presentations.
3. E-mail evaluations were sent to PE-pals and students at the conclusion of the course.
4. Instructor observation and reflection.

The central drawback of the first three modes was that anonymity was not possible, and with all the modes, evaluation was self-reported.

Although evidence suggests that while all the goals were met, there is room for improvement. The following sections delineate the outcomes in terms of goals met and areas for improvement.

Successes

An exciting aspect of the E-pal Program was that many of the goals were met in unpredictable ways. Some flexibility regarding due dates and the 'open-endedness' of the assignments afforded students and PE-pals time to communicate at their own pace and to discuss topics of interest to them. Table 3 summarizes the notable successes and corresponding goal(s).

There were two notable 'local' successes to the context of the students at Kenyatta University and their PE-pals that are underrepresented in Table 3. First, overall computer literacy was improved which directly addressed the third goal. Internet usage increased with regular e-mail interactions requiring more frequent computer usage. One student e-mailed the instructor two-thirds of the way through the quarter solely to express his pride in having an e-mail account. PE-pals often referred students to personal web pages and other common interest websites. Early attempts to send attachments demonstrated an additional capability of the Internet, although this proved to be unsuccessful due the low bandwidth available to the students. General computer literacy improved with students branching out to different softwares to capture information sent to them. Three students used PowerPoint® to produce slides for their final presentations; one had learned the software specifically for the presentation while the other two reported that this was their first chance to apply the material they learned in a computer literacy course.

The second 'local' success was the fostering of personal cross-cultural relationships. Approximately half of the relationships resulted in discussion of issues outside of assigned and technical topics. In some of these correspondences cultural and political issues were openly discussed, including dialogue on sensitive and emotive subjects such as the September 11th, 2001, tragedy in the United States. A number of students and PE-pals expressed that they felt they gained considerable insight into a different culture and region of the world.

Room for improvement

The first implementation of the Program demonstrated that better logistical planning was needed along with an improved method to address participants' expectations. Understandably, the most important logistic was ensuring that participants communicated in a timely and regular manner. However, because of personal and professional demands, prompt responses from PE-pals were not always possible. All participants had been informed of the time commitment, schedule, and responsibilities, but important obligations and vacation times prevented consistent and/or timely communication. This problem was addressed, and apparently rectified, with a request to PE-pals to inform their student when they were not able to respond immediately and the timeframe in which a response would be possible.

PE-pals spent anywhere from 15 minutes to an hour every two weeks communicating with their

Table 3. Select E-pal successes and corresponding goals.

Description	E-pal Goals addressed						
	1	2	3	4	5	6	7
Students were able to connect in-class theory with examples learned from PE-pals *at the time of material introduction.* For example, during an in-class small-group brainstorm of appropriate uses of Lagrangian and Eulerian frames of reference, a student paired with a microfluidics engineer cited to his group members 'particle separation around a micro-bend' as an example of when engineers needed to use a Lagrangian frame of reference. The linking of theory to examples provided by PE-pals extended beyond professions and work to a wide range of daily observations—airplane flight, weather, water flow from a faucet, etc.	✓	✓		✓			
Students were encouraged to seek out additional information in areas of interest. For example, the student paired with the pilot did independent research into aeronautics and the specific plane flown by the pilot. He then submitted a summary of this work as part of assignment 4.		✓		✓		✓	
The E-pal Program was a 'safe forum' to ask technical (and personal) questions. Whereas a student may be uncomfortable asking a professional, or even his instructor, questions face-to-face or in a public forum, the Internet and pen pal nature of the Program allowed students to be curious without social awkwardness.					✓		
Students were exposed to the daily tasks of industry and research. The day-to-day tasks and problem-solving of an engineer remain a mystery to many students until their first jobs. One student was surprised to learn from her PE-pal that food dye was commonly used in bioengineering testing instead of 'something more high tech'. Getting a glimpse of 'trench engineering' also exposed students to industry jargon and vocabulary.		✓			✓	✓	
Learning was fun. Many students stated that they preferred having foreign PE-pals because it offered the additional dimension of sharing and learning rather than purely technical dialogue. Printed-out photos and tales of PE-pals were circulated (in class often) amongst students shortly after being received.			✓				✓
Dialogues with PE-pals stimulated interest in graduate school and specific sub-disciplines. In many cases, students had not yet considered graduate school, the wealth of specialties, or the types of work and research in fluid mechanics. Interest in sub-disciplines was not confined to fluid mechanics, but also extended into other fields through their PE-pals.		✓			✓	✓	
Interest in Fluid Mechanics increased. Several students credited the E-pal Program and their PE-pals for their newly found ambitions to pursue careers in fluids-related fields.		✓					
Cross-pollination was possible. In one case, a student and PE-pal brainstormed on engineering projects together. The PE-pal was able to give some input as to potentially useful mechanisms for the student's design project in another class, while the student was able to relate some of the more popular modes for delivering power without fuel or electricity currently in use in Kenya.				✓			✓
PE-pals offered technical know-how beyond fluid mechanics. PE-pals demonstrated the range of technical activities involved in an engineering job by offering descriptions of their work and querying the students about their own interests. In one case, a student interested in programming, but without the time or money to take a course, was referred to a C++ tutorial website by his PE-pal.					✓	✓	
PE-pals and students independently discussed their respective dialogues and communications with peers also involved with the Program. Several PE-pals reported to the instructor that they sought out other PE-pals to discuss the Program and compare information they had learned from the students. Likewise, students discussed their PE-pals with each other.							✓
The Program provided a forum to discuss controversial and taboo issues. This was particularly evident regarding women in engineering. Dialogue occurred not only with female students paired with female PE-pals, but also in class following final student presentations. The hostilities encountered by African women in engineering in Kenya are infrequently discussed and are not usually addressed in a public forum. All three women students matched to female PE-pals independently reported that their female PE-pals were much-needed role models for them especially since there were so few women in engineering in Kenya.					✓		✓

students. When asked to rate whether this was 'too much time', 'just right', or 'would have liked more communication', approximately two-thirds of PE-pals selected 'just right', with the other one-third noting they would have liked more communication with the student. Results were generally similar for students, although the cost constraint was an obstacle for many.

By asking PE-pals to copy the instructor on these 'I'm swamped at the moment but will be

back to you in a few days' e-mails, a second logistical problem could also have been better negotiated: there were a few cases of students who failed to turn in assignments claiming that their PE-pals had not responded when in fact they had.

Several students reported that the brevity of the final presentation did not allow them to adequately present their range of experiences and emotions. It appeared that the presentation preparation prompted and provided impetus for student reflection, but the rigid time constraints truncated this process. These students were encouraged to submit further written work for extra credit, but none took advantage of this option.

From the instructor's perspective, the Program was work-intensive. Approximately 5–6 hours a week were dedicated specifically to communications with participants and E-pal assignment preparation and grading. Early preparation of information for PE-pals would mitigate much of this work. It is also likely that the time commitment for the instructor would be reduced in an environment with a better Internet and resource infrastructure other than that available in Nairobi. That said, however, the instructor found reading the memos very interesting, informative, and highly enjoyable.

In terms of expectations, for students accustomed only to lectures, problem sets and tests, the educational value of the E-pal Program was not readily obvious to the students. Memos from the first assignment reflected that many students were 'going through the motions'; their memos were verbatim of information from PE-pals' e-mails (evident from vocabulary and style of English used). However, as the semester progressed and students were able to link information from their PE-pals to course material, greater investment appeared to be put into the Program and the submitted assignments.

It appeared from the assignments that many of the student/PE-pal relationships were unbalanced and overly formal. Students were often shy or uncomfortable sharing information about themselves or deviating from assigned questions. PE-pals, on the other hand, may not have been properly encouraged to engage students. These behaviors are consistent with findings of studies of virtual teams: members geographically distant and dependent on only technological communication are less likely to share information freely than those who interact face-to-face [7]. Cultural differences and mismatched communication manners can also compound hindrances to communication. Information addressing these issues would have been helpful to all the participants, including the instructor.

Worth noting were three lessons learned specific to the context of running the Program in a less industrialized environment. First, there were some Internet growing pains for students who had not used e-mail before. This was compounded by an awkward class schedule and an academic culture unaccustomed to taking advantage of office hours. (The scheduled classes were spaced so that class meeting times were nearly a week apart; problems encountered Wednesday afternoons could not be addressed until Tuesday of the following week.) Second, at the time, the Nairobi Internet infrastructure was dependent on a central service provider that often went down and also generally did not allow for downloading large files. To address the latter, PE-pals and E-pals were ultimately discouraged from sending attachments which exceeded 50 Kb. Lastly, the financial costs to students for Internet usage were unexpectedly high. Although students at Kenyatta were allocated a block of free Internet and computer time per week, this did not come to fruition. As a result, students were forced to pay for Internet time at the university cyber café. They reported this expenditure over the course of the semester to be a 'moderate to high' impact on their semester budget. Students had several suggestions to address this problem, notably that the instructor should have encouraged them to set up 'frequent use' accounts at the cyber café.

DISCUSSION AND RECOMMENDATIONS

The E-pal Program has potential to offer benefits to students in a range of programs and at a variety of institutions. Two central advantages of the Program are that it provides a framework to bring valuable outside input into the classroom, and that it may be integrated at any academic level, from first year to final year courses. Integration of the Program with early coursework allows students to see the connection between engineering prerequisites and coursework, and also, coursework and engineering as a profession. Communication with PE-pals addressed the question almost every student asks: 'Why is this important for me to know?' Providing engineering students with readily-available resources to address this question is tremendously important for reducing attrition [8]. PE-pals were able to illustrate how equations are used in practice, how testing and measurements are done, and what considerations and assumptions can be made when trying to understand real-life engineering problems. The E-pal Program was an invaluable link for students in connecting the practical with the theoretical.

Even though the E-pal Program was intended to counter-balance the lack of resources at Kenyatta, an 'insider's look' into engineering practice is appropriate to any engineering course of study. Students at institutions the world over are not typically exposed to on-the-job engineering work with every subject; career choices are often based on classroom material likes and dislikes toward the end of an academic career. The strength of the E-pal Program is that it allows discipline-specific low-effort shadowing with embedded mentoring

which complements in-class teachings; students are introduced to a wide range of jobs and specialties to which they would not otherwise be exposed.

It is believed that the E-pal Program would be complementary and beneficial for any course of study *if* appropriate PE-pals are available and willing to participate. In fact, a few Kenyatta students outside of fluid mechanics (in computer science) contacted the instructor requesting to be part of the Program. The foundation of the E-pal Program is the diverse set of talents, interests, and experiences of the PE-pals who communicate with the students. The final presentations at the end of the year served to increase the impact of each PE-pal's input by reaching the rest of the class. Because PE-pals play an important role in guiding, mentoring, and sharing experiences with the students, it is recommended that a more extensive support structure be provided for PE-pals to keep them updated on class progress and activities (e.g., access to a class website), encourage communication with other PE-pals, and provide context-specific resources such as information about the university. One PE-pal suggested that a website be set up with such additional material.

Implications to teaching

The E-pal Program offered students non-traditional avenues for learning, achieving, and demonstrating knowledge. Of the five students with the highest E-pal marks, only one overlapped with the five students with the highest problem set/test marks. This is consistent with other research that has shown that 'traditional' assessment methods do not always distinguish students with greater material comprehension [9]. Correspondence, memos and the final oral presentation promoted critical thinking, reflection, and the communication of others' (often complex) ideas, their own ideas, and intermediary ideas. E-pal assignments encouraged students to move from the role of a question-answerer to a question-asker in their relationships with their PE-pals—something more commonly found in higher-level engineering course and research work.

Reports by the United States National Research Council have repeatedly called for better links between industry and the classroom to ensure an engineering work force that is internationally competitive [10]. Industry-academia partnerships in less industrialized countries are sparse to non-existent, something that must change with future goals of industrialization. The regular involvement of the PE-pals with the course promoted an industry- or application-orientation that was evident in small group, brainstorms and questions asked in-class. Comparison by the students of their PE-pals' information with their own local environment promoted exposure to different ideas, while at the same time, highlighting similarities that helped them plan for the future. The presence of and comments from the industry evaluators at the final presentation also assisted with this interpretation, and provided additional feedback from the local professional industrial perspective. Students commented that the opportunity to network with and receive input from the evaluators was extremely helpful in light of the dearth of jobs.

Mentoring

Chesler and Chesler describe the traditional mentoring model as a 'developmental relationship in which an experienced person provides both technical and psychosocial support to a less experienced person [11]. Although both types of information exchanges were encouraged through E-pal assignments, the nature of the Program as an extension of a course resulted in an emphasis on technical support by PE-pals. However, over half of the relationships did grow into mentoring relationships with both types of support. Most notable of these were the female-female pairs and those E-pals who shared common specific interests. These and other findings were consistent with the experiences of mentoring and Internet mentoring programs [12–14]. Note that technical support is 'knowledge-based', such as advice on solving a technical problem or applying for a first job, whereas psychosocial support addresses such issues as personality conflicts with project team members and balancing academic and personal responsibilities.

Using the Internet as a basis for fostering mentoring relationships between students and professionals is not new. Dozens of organizations within industry and academia exist to link students from kindergarten through graduate school to professionals, but almost all exist exclusively within industrialized countries. Best known for focusing on university students are Mentornet and E-Mentoring which both target women (and girls in the case of E-Mentoring) as a means of promoting science, math, and engineering careers. Mentornet, based at San Jose State University, matches female engineering students with industry mentors for year-long dialogues by e-mail [12]. Since 1997, Mentornet has connected over 7205 protégés with 6844 mentors. E-Mentoring, initiated in 1996 at Northeastern University, connects four to five girls and women in multi-generational Internet mentoring groups or 'E-Mentor Clubs' in the Boston area [13]. The authors are unaware of any other program like the E-pal Program which links students enrolled in a course to practicing professionals and researchers.

Sustainability and scalability

Circumstantial data from the United States suggest that innovative educational practices rarely see broad adoption, or even continuity [15]. Will the E-pal Program be any different? The challenges facing such a program after the champion departs are numerous, particularly in

less industrialized economies where lecture salaries are low, teaching loads are high, access to professionals is limited, and Internet connections are unreliable. Elmore argues that incapacity for continuity 'is rooted primarily in the incentive structures in which teachers and administrators work' [16]. While official numbers are unknown, approximately half of the Kenyan university lecturers queried 'moonlighted' or ran a business to supplement their academic incomes. Time to innovate—or even deviate from the norm—is unavailable. Elmore does note that a basic prerequisite for tackling such problems is to provide an explicit practical theory for implementation [16]. Assuming Internet connections and facilities will improve, the remaining major hurdles are tapping into a network of professionals and scaling the program appropriately for class sizes.

How might a lecturer without ready access to professionals find PE-pals? Several avenues exist: professional and social organizations on local and international levels, university alumni, industry acquaintances, and the contacts of contacts. For specialized recruiting on topics such as fluids mechanics, it may be possible to form partnerships with large university laboratories such as the Environmental Fluid Mechanics Laboratory at Stanford University or specialty branches of professional organizations such as ASME (American Society of Mechanical Engineers).

With reliable Internet connectivity and ready access to professionals, versatility in scaling the E-pal Program depends primarily on early planning and framework preparedness and assignment modification. Although a small program enables the instructor to troubleshoot issues as they occur, participants can address many of the problems themselves with suitable support information and interventions described in this paper. Mentornet's website offers mentor and student guides which cover a range of issues including cross-cultural communications, 'netiquette', participation responsibilities, and ideas for topics of discussion. Information such as this can and should be integrated into E-pal Programs regardless of size. For larger classes, student E-pal groups or theme sections based on interests may be an appropriate option. For assignments, student-generated web pages may be a suitable alternative to written assignments and final presentations.

Considerations for international programs

Execution of any program requires recognition of the cultural and social differences between individuals and groups, particularly if participants are internationally diverse, as in this case which involved pairing African students with North American professionals. Humor, manners of showing respect, politeness and greetings, work ethic, seniority and peer relationships, interaction between sexes, and many more societal nuances all differed. PE-pals were amused by the formality of the students and then sometimes confused with the brazenness of personal questions. Students, on the other hand, were often impressed with their PE-pals' work and efficiency, and wondered how they would be able to 'repay' their PE-pals with information about Kenya. For the students, there was also a 'wow' factor in having regular correspondence with North American engineers.

The role and background of the instructor is important for moderation and facilitation of cultural issues, although the instructor himself or herself must also recognize his or her own cultural framework. With the E-pal Program, the instructor felt it necessary to explain many aspects of Kenyan culture to the Western PE-pals, but failed to prepare students for the nuances of North American culture and recognize how the Program would consequently be impacted. For example, the instructor observed a tendency of PE-pals to minimize or avoid discussion of professional failures or personal difficulties. They often put their 'best foot forward,' inadvertently giving many students the idea that their PE-pals were 'geniuses' or 'superhuman'. (These terms were used to describe PE-pals during final presentations.) The tragedy of September 11th in the US, however, was a catalyst for some relationships to move past formalities to deeper discussions about hardships and personal issues.

The matching of two disparate economic groups offered benefits, but also presented an incongruity for students looking for guidance within their own system. For example, the difficulties of job-searching in Kenya are exacerbated by the omnipresent requirement of a *kiti kidogo* (Swahili for 'little thing', i.e. a little gift, or bribe) in securing an interview. Western counterparts likely have trouble relating to this serious impediment. Although preference was given to PE-pals from Kenya and other less industrialized regions, it would be recommended for international programs to place a higher emphasis on the recruitment of such PE-pals.

CONCLUSIONS

The E-pal Program proved to be successful in meeting its goals at Kenyatta University, although there is room for improvement. Most notable in its achievements were the fulfillment of the mechanics-related goals of demonstrating applications of in-class material and exposing students to the range of sub-disciplines, careers, and engineering problems in fluid mechanics. It also met an important 'local' professional goal of providing an impetus for all students to become Internet literate.

Many of the problems encountered in the Program can be easily avoided or navigated with foresight and planning. It is recommended that a greater support structure be available for PE-pals in which students and PE-pals are provided with

information on cultivating cross-cultural relationships. Furthermore, diligent consideration should be given to recruiting and matching appropriate PE-pals with students.

Analysis of future implementations should allow for anonymous surveys, authentic assessment, and long-term evaluation as this paper bases its findings on self-reported data immediately following the conclusion of the Program. Further assessment would produce more detailed insight as to how well goals are met and long-term outcomes are influenced by the Program.

The Program *virtually* brought engineering professionals and researchers into the classroom, allowing for students to catch 'real life' glimpses of engineering and how its practice relates to course theory. It is believed that the Program's approach and principles are widely applicable to almost any subject and location, providing interested and motivated professionals and affordable Internet resources are available.

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