Lifelong Learning Competencies Program for Engineers*

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Lifelong Learning (LLL) is critical for engaged citizens in the modern knowledge economy. The development of such generic or key competencies should be integrated throughout curricula, along with specific competencies in the disciplines such as engineering. This is a common educational goal in higher education in the USA and in Europe inside the Bologna Process. To enhance the capability of students to articulate their lifelong learning competencies, we developed a 'Lifelong Learning Competencies for Engineers' program for senior engineering students. This was presented as a workshop in a senior design course at the University of San Diego. The workshop includes presentations on lifelong learning competencies and specific recommendations for engineers, as well as an active learning exercise that helps students demonstrate their lifelong learning competence developed throughout their undergraduate career. Our mixed-methods evaluation reveals that the students improve their awareness of the importance of LLL at an important time in their lives as they finish their undergraduate academic career and move to the global labor market. Since lifelong learning spans disciplinary and national boundaries, this program could be adopted by other engineer educators and adapted by educators from a variety of fields.

Keywords: lifelong learning; key competencies, engineering education; professional development

1. Introduction

For decades, international organizations have promoted lifelong learning (LLL) as important for engaged citizens in the knowledge economy. For example, the United Nations (U.N.) Educational, Scientific and Cultural Organization (UNESCO) popularized the term 'lifelong learning' in the context of economic development and social growth [1, 2]. The European Union designated 1996 as the 'year of lifelong learning' [3]. U.N. Secretary General Kofi Annan in his Millennium Report said 'Education is the key to the new global economy, from primary school on up to life-long learning. It is central to development, social progress and human freedom' [4]. The World Bank promotes lifelong learning from an economic perspective as a way to develop human capital [5]. The Organization for Economic Cooperation and Development (OECD) [6] emphasizes that lifelong learning is important for economic development as well as equity, especially in developing countries. Lifelong learning is an important educational paradigm. 'Lifelong learning takes, as one of its principal aims, equipping people with skills and competencies to continue their own self-education beyond the end of the formal schooling' [7]. In some respects, the essence of 21st century employment is the ability to learn and adapt throughout one's working life. Thus, we expect educational systems at all levels and society as a whole to make evident to younger generations the value of LLL and give them the tools, desire, and responsibility to pursue it [8].

Universities play a critical role in promoting lifelong learning through research on the topic, training of teachers to believe in the importance of lifelong learning and serve as role models, and providing learning experiences that encourage students to continue learning throughout their lives [3]. Lifelong learning competencies are often included in program goals for higher education. For example, lifelong learning is an explicit part of the outcomes in the European Higher Education Area (EHEA), where all university graduates must 'have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy' [9]. In the United States of America (USA), ABET, the accreditation body for engineering and technology [10], includes the requirement that engineering graduates should have 'a recognition of the need for, and an ability to engage in lifelong learning'.

Given how critical lifelong learning skills are for all citizens of the modern global community, it is important that efforts to address development of these skills be done with an international and multidisciplinary approach. We capitalized on a unique opportunity for such a collaboration between an Education professor from the National University for Distance Education (UNED) in Spain and an Engineering professor at the University of San Diego (USD) in the USA. We wanted to help

higher education students (specifically engineers) better understand and articulate their lifelong learning competencies. To accomplish this goal, we developed a program on lifelong learning competencies that was delivered to a group of seniors majoring in engineering. We reviewed a large body of literature on lifelong learning and decided which material would be most useful for these students. In this paper, we describe the information on lifelong learning competencies and specific recommendations in the domain of engineering that we incorporated into our program. Then we present the logistics of the program, including examples of presentation slides and an active learning exercise. Next we use a mixed-methods approach to evaluate the program's efficacy and students' satisfaction. Finally, we conclude with some recommendations for higher education.

2. Lifelong learning competencies

2.1 Lifelong learning concept

Lifelong learning is defined as 'intentional learning that people engage in throughout their lives for personal and professional fulfillment and to improve the quality of their lives' [11]. The major characteristics of LLL are contained in its name: 'Lifelong' from cradle to grave and 'Learning', not instruction; learners are responsible for their own learning processes [12]. Educators play a critical role in the complex process of the development of students as lifelong learners. Their pedagogical choices can have significant impacts on students' future as learners [13].

2.2 Competencies and key competencies

Two elements are crucial in the meaning of competence: applying what one knows and what one can do to a specific task or problem and being able to transfer this ability between different situations. Gonczi [14] describes competency as 'the ability to successfully meet complex demands in a particular context, through the mobilization of knowledge, cognitive skills but also practical skills, as well as social and behavior components such as attitudes, emotions, and values and motivations.' 'Competence' supposes knowledge, skills, attitude and values; 'skills' also supposes knowledge, but a person could be an expert in a concrete skill and not possess the fundamental knowledge needed for applying that knowledge in practice. The broadest meaning of 'competencies' is adopted by the European Bologna process with the objective of training students in the EHEA by competencies. In the

USA, outcomes-based education is often based on competencies.

The goal of traditional education is to provide students with useful knowledge. However, the focus has often been on adding different topics rather than leaving enough time to contextualize and apply, in real life situations, the topics that are studied. Competence-based education requires creating a learning setting in which the transfer of knowledge, supported by a reflective practice, can occur in situations that allow individuals to mobilize their knowledge, combine it, and go beyond it [15]. Competencies are based on domain-specific knowledge that is to be applied in present and, more importantly, in future practice. Thus what and how one has to learn should result from requirements of practice, not from tradition or authoritative principles. Competence-based learning is often described in terms of transfer from learning to practice, situated learning, and tacit knowing [16].

There are two main types of competencies: *Specific Competencies*, which include concrete 'technical' knowledge in a specific area, i.e. Engineering, Medicine or Education; and *Key Competencies* also known as generic, transdisciplinary or transversal competencies, which are shared by all professionals such as communication, teamwork, or information technology literacy. Lifelong learning competencies in today's knowledge society require specific key competencies, such as knowing what one has to learn, knowing what one does not know, and knowing where to find relevant information. Because of the increasing amount and the changing nature of technical knowledge, the need to keep up with change is even more critical today. The need to understand and anticipate change highlights the importance of lifelong learning. According to the OECD Definition and Selection of Competencies (DeSeCo) Project, [17] key competencies may be classified in three broad categories:

1. Individual Competencies: to be able to interact effectively with the environment (*Socio-cultural* such as the use of language and *Physical* such as Information Technology).
2. Relational Competencies: to be able to engage with others and interact in heterogeneous groups.
3. Autonomous Competencies: to manage one's own life responsibly in the broader social context.

These three categories are interrelated and form a basis for identifying and mapping key competencies. The need for individuals to think and act reflectively is central to this framework. Being reflective involves not just the ability to routinely apply a formula or method for confronting a situa-

tion, but also the ability to deal with change, learn from experience and think and act with a critical stance. We briefly describe the three groups of key competencies below.

Key competency category 1: Using tools interactively
Individuals encounter the world through cognitive, socio-cultural and physical tools. These encounters, in turn, shape how they make sense of and become competent in the world, deal with transformation and change, and respond to long-term challenges. Using tools interactively opens up new possibilities in the way that individuals perceive and relate to the world. People need to keep up to date with technologies, to adapt tools to their own purposes and to conduct active dialogue with the world. Today's lifelong learners must possess 'information literacy' so that not only can they use information technology tools, but they also are able to search for, find, manage and evaluate the merits of the information found [18–21]. Three subcategories are contained in this first group:

- Use language, symbols and text interactively.
- Use knowledge and information interactively.
- Use technology interactively.

Key competency category 2: Interacting in heterogeneous groups
Relating well to others allows individuals to initiate, maintain and manage personal relationships. Individuals are able to respect and appreciate the values, beliefs, cultures and histories of others. Successful citizens need to deal with diversity in pluralistic societies, empathize with others and relate to others. Three subcategories are contained in this second group:

- Relate well with others.
- Cooperate, work in teams.
- Manage and resolve conflicts.

Key competency category 3: Acting autonomously
Individuals must act autonomously to participate effectively in the development of society and to function well in different spheres of life, including the workplace, family and social life. Acting autonomously includes three subcategories:

- Act within the big picture, subject to duty and obligations.
- Form and conduct life plans and personal projects.
- Defend and assert rights, interests, limits and needs.

Lifelong learning is a critical part of formal and informal learning and it underlies these key compe-tencies defined in OECD's DeSeCo project. Thus those three broad categories may be considered as a framework for demonstrating lifelong learning competencies.

2.3 Lifelong learning competencies

Competence is conceptualized as an action verb. Thus displaying lifelong learning competence involves taking action, making decisions, and solving problems. The World Bank, in its report on 'Lifelong Learning in the Global Knowledge Economy' [5], says that 'Preparing workers to compete in the knowledge economy requires a new model of education and training, a model of Lifelong Learning' and adds: 'Educational systems can no longer emphasize task-specific skills but must focus instead on developing learners' decision-making and problem-solving skills and teaching them how to learn on their own and with others.' Schools should emphasize decision-making skills, dialogue, participation and the ability to take charge of one's own learning, rather than arming pupils with knowledge that can become obsolete.

Within the frameworks of educational and competence development, important concepts that underpin lifelong learning are personal and social competencies that include self-directed learning, metacognitive awareness, and the disposition to learn [11]. Self-directed learning is one of the most popular ideas to emerge from the lifelong education discourse [22]. Extensive research has been done in these areas including that by Knowles [23], who describes self-directed learners as those who develop a personal learning plan based on self-assessment of prior knowledge, continue defining their learning goals in accordance with their personal and professional goals, actively search for useful learning resources and strategies, and finish with evidence of accomplishment. Closely related to self-directed learning is self-regulated learning (SRL) [24, 25]. SRL emerged from research in educational psychology on student motivation and learning in which learners are viewed as active participants in the learning process. Much of the work on SRL has been done with college students where instructors usually set the overall learning goals but students choose the motivations, strategies, behaviors, and attitudes that they adopt to enhance their learning.

3. Lifelong learning competencies for engineers

As students make the transition from the university to the workplace, it is important for them to recognize that their employability in the modern global economy is rooted in their ability to adapt to a variety of different job requirements throughout

their careers. Those who can best display such lifelong learning competence are likely to be most successful. Today, individual employees are expected to show initiative, independence, and critical thinking skills. To be competent is to be able to learn to adapt and respond to new situations i.e. to continue to learn throughout one's life [15]. One who possesses professional competency has knowledge, skills, attitude and values necessary to practice a profession, can solve professional problems in an independent and flexible way, and has the capability to collaborate in his/her professional environment, using and transmitting information to others.

Lifelong learning is particularly important for complex fields with rapid technological change such as engineering. Engineering leaders have recognized this and included lifelong learning in the ABET accreditation outcomes that graduates of engineering programs must achieve. Thus engineering educators throughout the world have been grappling with how to help their students develop as lifelong learners and how to assess this growth [26–32]. Continuing professional development for engineers is also a topic of research and activity by engineering professional societies such as the Institute for Electrical and Electronics Engineers (IEEE) [33–36]. John Meredith, a former president of IEEE USA, has written a useful resource with specific practical guidelines to help students develop as professionals in the field of engineering [37]. The focus on a career in industry as an engineer overlaps with many students' goals and helps make this book relevant. Key ideas from this book are summarized here and were included in the 'LLL Competencies for Engineers' program.

The personal development plan
Meredith strongly recommends taking an active role in ensuring that one is a lifelong learner by developing a Personal (and professional) Development Plan (PDP) early in one's career. This plan should be frequently updated and serve as a guide for achieving career and personal goals. Meredith describes the process as:

- Perform an assessment of your knowledge, skills and social network against the requirement of your new job.
- Identify important gaps that you will need to fill in the initial phase of your professional career.
- Prepare a checklist of learning and development tasks with time goals.
- Check your progress periodically to ensure your continued career development.
- Update your plan focusing on key generic competencies and specialized and technical training.

Organize your work environment
In the work environment, being organized can greatly assist one's development. This includes organizing one's office and personal computer so that they support daily work activities. It is also very important to organize physical and computer filing systems to maximize efficient retrieval of information. Developing abilities to share information with colleagues is beneficial to one's PDP and future success.

Improve your generic key competencies: Reading to learn and collaborative work
For practicing engineers, is important to improve key competencies such as: oral presentations, writing reports and memos, organizing meetings, interpersonal relations, project management and planning and budgeting, among others. A particularly important competency for personal, professional and social development is reading as a strategy for continued learning. Reading technical literature is one of the most effective ways to keep up to date. Engineers need to develop the abilities to read quickly and identify the material that is most useful. Interacting with authors working in common technical areas is a good strategy for professional development. Appropriate reading material for engineers should not be limited to technical topics but go beyond it.

Working in collaborative groups with colleagues who are interested in the same subject can also help with professional development. In collaborative work, all team members share their efforts to achieve the team's goal, contribute to solving problems, improve work, and innovate. Such collaborations provide synergies that are more than the sum of the parts.

Enhance your competencies on-the-job
To improve competence on the job, Meredith recommends seeking out and working on challenging leading-edge projects. By identifying resources, one can find data and information for future projects. Advice from experts can be very valuable. Engineers should seek out mentors including previous professors and colleagues.

Memberships in professional societies
To be up-to-date, it is important to join relevant technical professional societies. For engineers, this includes societies such as the IEEE, the American Society of Mechanical Engineers (ASME) [29] and the Society of Women Engineers (SWE) [30]. Professional organizations offer many opportunities to network with other professionals and to attend technical and professional development activities (i.e. conferences, meetings) as well as tutorials to

learn about emerging technologies and other technical topics. A more ambitious goal is to present a paper at a conference about a project. This helps engineers to clearly describe their project and its status, practice communication, and obtain feedback. Subsequent publication in a journal could be an extrinsic goal that enhances motivation for continuing learning and effort.

In summary, lifelong learning requires engineers to take responsibility for their own development, and developing habits to improve learning effectiveness. A career that 'embraces a program of continuous learning will ensure that you have a successful career: a career that is filled with many proud accomplishments—a career that earns you respect from your colleagues—a career that is fun and exciting' [37].

4. A lifelong learning competencies program for engineers

4.1 Design

We used the theories and frameworks described in Sections 2 and 3 to develop a targeted program for seniors majoring in engineering. Certainly, lifelong learning competencies must be developed throughout the curriculum. In this case, this program builds upon work done throughout the curriculum and, unlike other approaches, helps students to learn more about the idea of lifelong learning and to be able to articulate more clearly how they have developed such competencies at this point in their careers.

We worked within the constraints of a particular curriculum in engineering in a specific course that required students to provide demonstration of an appreciation for lifelong learning as part of a portfolio used for overall program accreditation. Since the students are in their last year of their undergraduate curriculum, it is important to help them recognize what they have already done as lifelong learners, articulate evidence for this, and realize the importance of continuing to learn throughout their careers as engineers. Thus we chose to provide specific information about frameworks and literature on lifelong learning. We also included an active learning exercise to help students engage with this material and demonstrate their competence. Such active learning enhances student learning [40]. We encouraged students to think broadly about how this information intersected with their own experiences throughout their college careers.

As designed, this program overlaps with five of the ten 'practical ways engineering programs can promote the development of lifelong learning' suggested by Riley and Claris [30]. Specifically, it involves students directly in the ABET accreditation process, uses learning methods and classroom activities that support lifelong learning [41], includes opportunities for reflection, involves a portfolio, and builds interconnections to other disciplines, co-curricular activities, and student lives.

4.2 Context

This workshop was implemented within ELEC 492 Electrical Engineering Design and Practice II at USD. ELEC492 is the second course in a two-semester electrical engineering (EE) senior capstone design sequence. In 2010–2011, the instructors chose sustainability as a theme for all projects [42]. Mechanical engineering (ME) students were invited to participate on projects where their skills would be beneficial. This resulted in five projects with three interdisciplinary teams including 16 EE and 5 ME students. The focus of these courses is the design project. The first semester includes the proposal and preliminary design phases including two formal reports and presentations to their peers, instructors, and other faculty. The second semester focuses on design, construction and test. This includes a Critical Design Review and Final Design Review, both of which include a formal report and presentation. The project culminates with a public demonstration at the USD Engineering Open House.

In addition to the design project, these courses were also chosen by the USD Electrical Engineering faculty to provide demonstration materials for ABET assessment, faculty review, and program improvement. Specifically, students must demonstrate achievement of most ABET outcomes including lifelong learning via a portfolio. One of the course outcomes for ELEC 492 stated on the syllabus is

> Each student will present results from various professional development activities, and other activities engaged in prior to the course in a portfolio of his/her work that demonstrates design abilities, teamwork skills, ethical understanding, communication abilities, and recognition of the need for and ability to engage in life-long learning.

Given that demonstrating lifelong learning is an explicit part of the course, ELEC 492 was an appropriate place to implement the 'Lifelong Learning Competencies for Engineers' program. The program was offered a week before the deadline for students to submit a draft of their portfolio.

4.3 Workshop

The 'Lifelong Learning Competencies for Engineers' workshop was delivered in April 2011 to the 21 students enrolled in ELEC 492 at USD. This program was presented in a 1.5 hour workshop consisting of three parts: Part I—a presentation on lifelong learning competencies development based on the topics described in Section 2, Part II—an

active learning exercise, and Part III—a presentation on lifelong learning competencies for engineers based on the topics from Meredith's book described in Section 3. Students were given handouts of the PowerPoint slides used in Parts I and III. Examples of PowerPoint slides are included in Figs. 1–5 for Part I and Fig. 7 and 8 for Part III and copies of all slides are available from the authors.

Part I: Lifelong Learning Competencies Development

The outline of this presentation of the theory of lifelong learning based on the material in Section 2 was:

- Introduction and USD Goals
- Lifelong Learning Concept
- Competence Concept
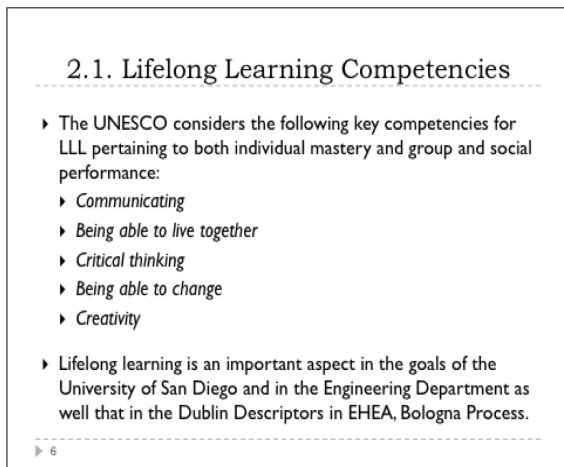- Key Competencies
- Summary: Intentional Lifelong Learning.

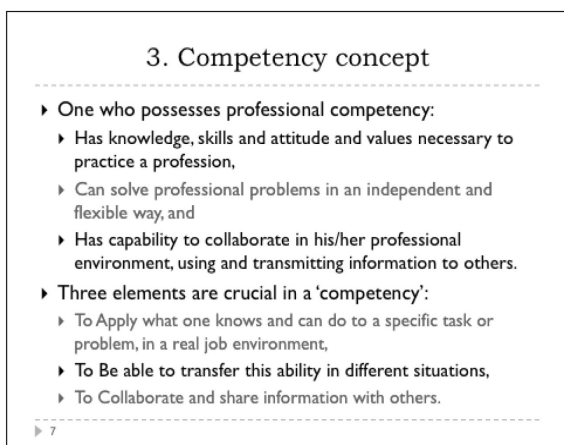**Fig. 1.** Slide on lifelong learning competencies used in Part I of workshop.

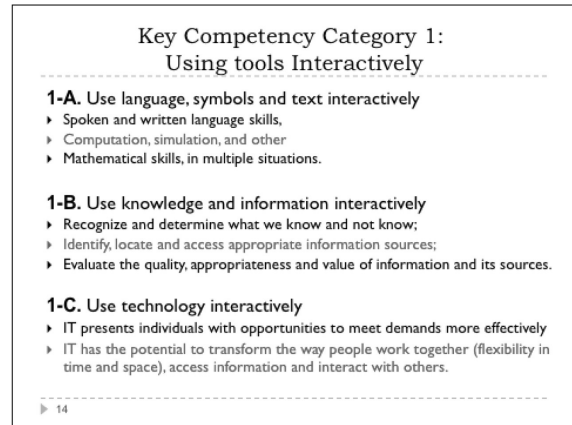**Fig. 2.** Slide on concept of competency used in Part I of workshop.

Fig. 3. Slide on using tools interactively used in Part I of workshop.
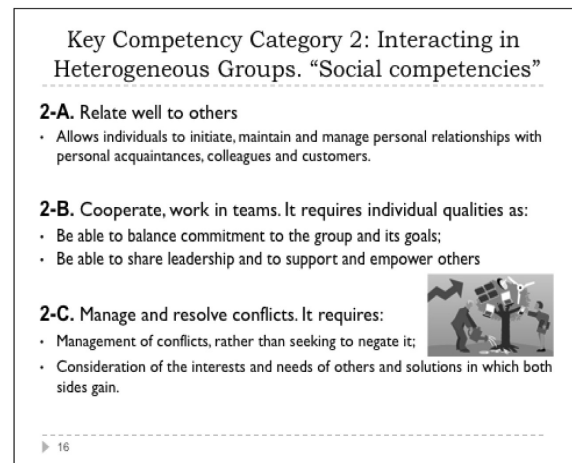

Fig. 4. Slide on interacting in heterogeneous groups used in Part I of workshop.
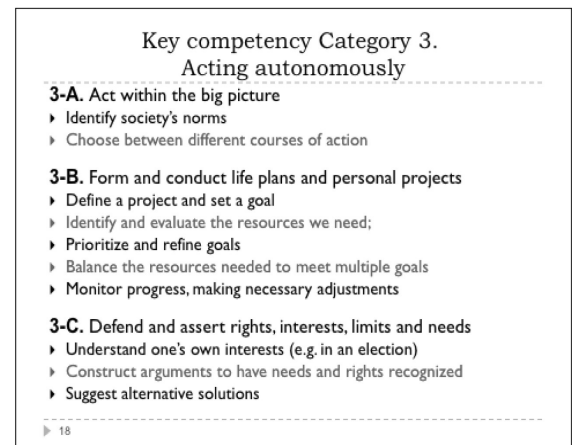

Fig. 5. Slide on acting autonomously used in Part I of workshop.

Part II. Active learning exercise
For Part II, the students performed a think–pair–share exercise using the worksheet shown in Fig. 6. Students related key competencies for LLL to what they have learned during their career at USD. This was intended to help them articulate the LLL that is embedded in the academic curriculum and take responsibility for their personal and professional development.

ABET requires that engineering graduates demonstrate a 'recognition of the need for, and an ability to engage in life-long learning' (outcome i). You must demonstrate achievement of this outcome in your Portfolio for ELEC 492. Let's apply some of the ideas from this workshop to your own experience to help in your portfolio preparation.
1. Please fill out this table with examples of how you have demonstrated each of these competencies during your senior design project.

Lifelong Learning Competency	Examples from Senior Design Project
Use tools Interactively	
Act Autonomously	
Interact in heterogeneous groups	

2. Please fill out this table with examples of how you have demonstrated each of these competencies during your years at USD other than in your senior design project.

Lifelong Learning Competency	Examples from USD
Use tools Interactively	
Act Autonomously	
Interact in heterogeneous groups	

3. What materials could you provide in your Portfolio to demonstrate your competency in these aspects of lifelong learning?

Fig. 6. Exercise on lifelong learning used in workshop.

Part III. Lifelong Learning for Engineers
The third part of the workshop was about specific competencies working as an engineer, related to generic or key competencies. The outline of this presentation followed Meredith's book as described in Section 3:

● The Importance of Lifelong Learning
● Plan for Continuing Professional Development
● Organize Your Work Environment
● Working as an Engineer
● Enhance Your Competencies On-the-Job
● Improve your Learning Process
● Graduate School?
● Memberships in Professional Societies
● Summary: Lifelong learning never ends.

Figures 7 and 8 are examples of the material as presented to the students.

2.2. Improve your Generic Competencies

■ One-on-one communications
■ Oral presentations
■ Writing reports and memos
■ Organizing meetings
■ Interpersonal relations
■ Project management
■ Planning and budgeting

Learn by doing. Stay involved. Tap peer expertise.

Fig. 7. Slide on improving generic competencies used in Part III of workshop.

10. Professional Societies
Join IEEE, ASME, or other relevant societies !!

■ Professional organizations offer many opportunities to:
  ■ attend educational technical and professional development activities (conferences, meetings)
  ■ network with other technical professionals
  ■ broad array of publications to help you keep current
  ■ tutorials to learn about emerging technologies and focused topics of interest to the leading-edge technologist
■ A higher level goal would be to present a paper at a conference.
■ After your presentation, you always receive more than you give.

Fig. 8. Slide on professional societies used in Part III of workshop.

5. Evaluation of the program efficacy and students' satisfaction

5.1 Evaluation methods

The evaluation of the program efficacy, students' satisfaction, and impact was done using a mixed-methods approach with statistical analysis of Likert-scaled questions on pre- and post-surveys as well as content analysis of open-ended questions on the surveys and on the students' portfolios. Since there were only 21 students in our study, analysis of the qualitative data is particularly important to add validity to the quantitative results.

5.1.1 Data and sample

A survey was conducted electronically, before and after the workshop. The pre-survey included ten Likert-scaled questions where students responded from 'strongly agree' (5) to 'strongly disagree' (1) and five open-ended questions. The post-survey included the same questions as the pre-survey, plus two Likert-scaled questions on the workshop itself and another two open-ended questions asking for feedback on the workshop.

We also collected and analyzed the students' sections of their portfolios where they were asked to demonstrate the ABET outcome i) 'a recognition of the need for, and an ability to engage in lifelong learning'. They were instructed to provide a written description of demonstrating this outcome as well as evidence. Most wrote about one paragraph. Some wrote more than a page.

The sample for this study consisted of the 21 senior engineering students enrolled in ELEC 492 at USD in Spring 2011. All 21 were invited to participate in the surveys by means of a letter describing the IRB-approved research and containing a link to the on-line survey. Sixteen students completed the pre-survey and twelve of these completed the post-survey. All 21 students submitted a portfolio.

5.1.2 Quantitative and qualitative methods

Data analysis of the Likert-scaled items on the surveys was performed using the statistical program SPSS. V.17 and included descriptive analysis and a hypothesis test (t of Student's test or t-test). Our hypothesis was that 'The program on 'Lifelong Learning Competencies for Engineers' would improve the students' competencies for Lifelong learning'. (Statistical hypothesis: $M1 < M2$). The null hypothesis was that 'The program on 'Lifelong Learning Competencies for Engineers' would not improve the students' competencies for Lifelong learning'. (Statistical hypothesis: $M1 = M2$) The significance level (α) to test our hypothesis was chosen to be 0.05.

Content analysis was used to analyze the open-ended question and the students' portfolios. Krippendorff [43] defines content analysis as a technique designed to formulate, based on certain data, reproducible and valid inferences that could be applied to a context. Content analysis is a research technique applied to documentation (verbal, written or recorded, or nonverbal such as drawings, photographs, or videos) whose purpose is to identify the semantic content of the documents under review and deduce inferences by identifying objective and systematic characteristics of messages contained in the documents. Given the manageable size of our information to be analyzed, the researchers read through the data searching for key terms, categories, and counted the frequency of their occurrence [44].

For the open-ended questions, student responses on the pre-survey were compared with the concept involved in the question and then classified as 'no answer,' 'incomplete', or 'good'. For the post-survey, the student responses were classified as 'no answer,' 'incomplete,' 'still good,' or 'improved.' The 'still good' category included responses that were good before and after the workshop. The 'improved' category included responses that went from 'incomplete' at pre-survey to 'good' at post-survey. The criteria for analyzing the students' portfolio sections on lifelong learning were relevancy of the contents to the workshop topics and frequency of their mention.

5.2 Results of data analysis and discussion

5.2.1 Quantitative analysis: Likert-scaled survey questions

The results of the descriptive analysis of the Likert-scaled questions on the pre- and post-surveys are shown in Table 1. The highest agreement in the pre-survey was on items 2 'Lifelong learning is important for engineers' and 3 'I believe general competencies are important for success in my career.' Item 2 obtained the highest agreement on the post-survey rising to 4.91 (from 4.68 in the pre-survey), very close to the maximum possible value of 5.0. The second highest agreement on the post-survey was for item 1 'Learning to learn is an important concept for personal development' which had been third in the pre-survey. For the post-survey, Item 3 became the third highest item tied with Items 4, 5, and 10.

In the post-survey, we observed higher agreement in the students' responses to all but one of the questions asked. This suggests that the workshop on lifelong learning helped the students learn about this topic. Only item 3 had a lower value in the post-

Table 1. Comparison of the means on items in the pre- and post-survey

Question	Pre-survey (N = 16) Mean	Post-survey (N = 12) Mean
1. Learning to learn is an important concept for personal development.	4.62	4.73
2. Lifelong learning is important for engineers.	4.68	4.91
3. I believe general competencies are important for success in my career.	4.68	4.64
4. Reflecting about my current knowledge can help me to improve my future performance in my career.	4.37	4.64
5. Organizing my computer filling system could contribute to my professional success.	4.25	4.64
6. Collaborative work is important to solve complex problems.	4.37	4.55
7. I have some clear ideas about how to prepare my personal development plan.	3.31	4.00
8. The Internet offers many opportunities for learning.	4.31	4.55
9. My USD education has prepared me to be a lifelong learner.	4.06	4.36
10. Personal development is the responsibility of all professionals.	4.50	4.64
11. I expect to improve my professional competencies by using some of the ideas presented in this workshop.	*	4.27
12. Overall, I am satisfied with how easy the ideas presented in this workshop apply in my personal development.	*	4.18

* Not in pre-survey.

survey (4.64 vs. 4.68), but it is a very small difference and might be attributed to the students' responding more honestly when they better understood the meaning of the term 'general competencies' after the workshop. Question 7 'I have some clear ideas about how to prepare my personal development plan' received the lowest agreement in the pre-survey as well as in the post-survey. However, in both cases, it was above the neutral value of 3, and the increase from pre to post that suggests students gained knowledge of personal development plans as result of the workshop. The students' evaluation of the workshop itself on items 11 and 12 on the post-survey indicates a high level of satisfaction with the workshop and how they could apply the information presented.

In Table 2, we show the analysis of the ten common Likert-scaled questions for the two surveys. The means in the pre and post-survey are high: 4.31 and 4.57, respectively, but higher in the post-survey. This can be interpreted as the students increasing in their recognition of the importance

of lifelong learning for their professional development as engineers after the workshop.

To determine if the differences in means between pre and post survey are statistically significant, we conducted a t-test of one sample of repeated measurements. The t-value obtained gives a statistically significant difference at a level of 0.000 (0.000 < α = 0.05). These results show that the students in our sample gained knowledge after the presentation of the program 'Lifelong Learning Competencies for Engineers' proving our hypothesis. These results are promising. Given our small sample size, however, they cannot be generalized. Future work with more students is needed to address this limitation.

5.2.2 Qualitative analysis: Open-ended questions in pre- and post-surveys

A summary of the content analysis of the five common open-ended questions is shown in Table 3 for the pre-survey and Table 4 for the post-survey. More details for each question are provided in Tables 5–9. In each of these tables, the question, a statement of the correct concept, and examples of student responses for each category is included.

In summary, 49% of the responses provided by the sixteen students who participated in the pre-survey demonstrated good knowledge on the topic of lifelong learning. On the post-survey, 38% of the

Table 2. One-sample statistics for ten common items

	Mean	Std deviation	Std error mean
Pre-survey	4.31	0.406	0.128
Post-survey	4.57	0.253	0.080

Table 3. Content analysis on the pre-survey (N = 16)

Concept	No answer	Incomplete	Good
Lifelong learning	0	6	10
Professional competency	1	8	7
Self-assessment	0	9	7
Collaborative work	0	6	10
Personal development plan	1	10*	5
Total	2 (3%)	39 (49%)	39 (49%)

* Includes six responses of 'I don't have one [personal development plan]'.

Table 4. Content analysis on the post-survey ($N = 12$)

Concept	No answer	Incomplete	Still good	Improved
Lifelong learning	3	0	4	5
Professional competency	3	2	4	3
Self-assessment	3	2	3	4
Collaborative work	3	0	3	6
Personal development plan	3	3*	1	5
Total	15 (25%)	7 (12%)	15 (25%)	23 (38%)

* Includes two responses of 'I don't have one'.

Table 5. How do you define 'Lifelong learning'?

Concept: Lifelong learning is intentional learning that people engage in throughout their lives for personal and professional fulfillment and to improve the quality of their lives.

Pre-survey	Post-survey	Valuation
Learning through everyday experience.	The same as I said before.	Incomplete
Constant growth in your knowledge.	[no response]	Good
The understanding that it is important to continue to learn throughout your life. Not just when you are in school.	The ability and desire to continue learning throughout your life.	Improved

Table 6. How do you define 'professional competency'?

Concept: One who possesses professional competency has knowledge, skills and attitude and values necessary to practice a profession, can solve professional problems in an independent and flexible way, and has the capability to collaborate in his/her professional environment, using and transmitting information to others.

Pre-survey	Post-survey	Valuation
Knowledge of the general business practices in a company and general knowledge about the particular field in which you work.	Knowledge about your particular field.	Incomplete
The ability to fully understand the work that you are doing . . . without significant chance of failure.	The ability to fully understand what you are working on and put your full effort into your work.	Good
Competent in professional matters.	The application of knowledge and skills in a professional environment.	Improved

Table 7. What is the purpose of a self-assessment?

Concept: The purpose of a self-assessment is to obtain information based on a comparison between what we need to solve a task or a problem and what we know to guide the decision to improve.

Pre-survey	Post-survey	Valuation
To evaluate yourself on your own terms.	To understand more about your personal work.	Incomplete
Self-assessment gives you a clear idea of what areas you need to work on to make yourself better.	Self-assessment helps a person to identify the areas of professional competencies that they need to work on.	Good
Assessing one-self to determine strengths and weaknesses.	A self-assessment means to reveal strengths and weaknesses to determine areas of improvement.	Improved

responses showed an improvement after the workshop and 25% were good before and after the workshop. The remaining students provided either no response or an incomplete response. Considering that nine students completed the open-ended questions in both surveys, 51% of their responses improved after the workshop and an additional 33% of the responses were good before and after the workshop. These results suggest that the students started with a good foundation on the topic of lifelong learning competencies from their careers at USD. However, the workshop was helpful for many of them with about one-third of the survey respondents (5 out of 16) demonstrating improvement in their knowledge after the workshop. (Note that this is 24% of the entire class: 5 out of 21 students.) Consistent with the quantitative results, the qualitative data also show that the workshop was particularly beneficial for imparting knowledge about personal development plans. 'I don't have one' was the most common response before the workshop but most students who responded on the post-survey had a good response in summarizing their PDP.

Table 8. What are the main advantages of collaborative work?

Concept: Collaborative work (CW) involves working together, sharing efforts, making it easier to achieve goals and solve problems, improve our work, and innovate.

Pre-survey	Post-survey	Valuation
To evaluate yourself on your own terms.	To understand more about your personal work.	Incomplete
Team building, multiple ideas, complete work faster, learn from others and develop higher level thinking skills.	[no response]	Good
CW helps when you can not solve a complex problem talking to other people to get their view of the problem can lead you to gain new insights and knowledge.	CW broadens your perspectives by providing you insight into other people's perspectives of a situation.	Improved

Table 9. Please briefly summarize "your current personal development plan".

Concept: The personal development plan is based on the self-assessment. This includes necessary learning resources, activities, courses, a planned sequence and reflection.

Pre-survey	Post-survey	Valuation
My current personal development plan is to be able to communicate on a more understanding level.		Incomplete
To continue to earn a doctoral degree. Once this is finished to work in a national laboratory or in academia.	Graduate school, make a name for myself, become a better speaker, become a professor.	Good
Getting a job where the tasks assigned motivate me.	Getting an international job to develop personally and keep growing as a professional	Improved

5.3 Workshop evaluation

Seven students provided responses to the two open-ended questions on the post-survey about the most valuable aspects of the workshop and those that needed improvement. Overall, this data shows that the students were engaged and believed they learned some important information on lifelong learning competencies. Five students commented on the value of the information provided including the personal development plan and key competencies. Four students cited the interactive aspects of the workshop as valuable, including the exercise and discussions with peers. One student nicely summarized these two valuable aspects saying: 'Interactive worksheet in groups applied the information to our current work. It was good information that had not necessarily been presented to us previously.' Only one student thought the workshop was not 'helpful during the undergraduate stage of my career.' However, another student specifically cited the workshop in his portfolio saying it 'gave a useful outline to ensure that we understand the importance of lifelong learning.' The most common area for suggested improvements was in providing more examples including personal examples, real life situations, and details on personal development plans. A few students also recommended improving the presentation quality including adopting a more dynamic style, more interaction, and fewer slides.

5.4 Portfolios

Our content analysis of the portfolios confirmed the results of the surveys and showed that the workshop had a significant impact on the participants. The students were able to articulate their LLL competencies developed throughout their university career using terms that were used in the workshop. Notably, 20 of the 21 students (95%) specifically or implicitly included some information from the workshop in their portfolios. Four students mentioned the workshop with two of these including the workshop handouts. Two students made a specific reference to Meredith's book. Three used the three broad categories of key competencies described in the workshop to organize their demonstration materials. These students used examples that were discussed during the active learning exercise of Part II of the workshop. For example, one student mentioned learning to use tools such as ProEngineer Wildfire 5.0, interacting in a heterogeneous group with people from different cultures, and attending a leadership training seminar and graduate student technical conference as evidence of actual and future commitment to lifelong learning. In their examples, many students drew upon their responses to the active learning exercise, considering not only experiences within engineering but also courses in areas such as public speaking and ethics, as well as extra-curricular activities such as athletics.

Ten students highlighted the importance of being a member of professional societies such as the IEEE or ASME to find opportunities for training and establish professional relationships and networks worldwide. Seven students mentioned topics that were discussed in the workshop including the importance of staying current as an engineer, the importance of lifelong learning, continued learning,

remaining a strong member of the work force, learning never stops, technology changes rapidly, and the value of mentors as well as working collaboratively in groups to share experiences, knowledge, and develop relationships.

5.5 Discussion

This program on LLL competencies for engineers was effective. The students gained information after the workshop and expressed satisfaction with the contents and activities. Students gained a better understanding of the importance of LLL concepts throughout the world and their individual need to develop their generic competencies in addition to their specific technical competencies. Students had the opportunity to apply what they learned in an exercise where they connected the discussion of LLL strategies and key competencies to their own experiences. This helped them to take responsibility for their personal and professional development.

A limitation of this work is that it has been done with only one group of students at one institution in one country. Incorporating the suggestions from this first group of students, we intend to repeat this workshop with several groups at different universities in different countries. We plan to conduct the workshop with students in their last year at the University of Plovdiv and the Technical University of Sofia (TUS), both in Bulgaria, and also in Spain, at UNED, with engineering students. Increasing the sample size will improve the validity and generalizability of the results.

6. Conclusions and recommendations

In a multidisciplinary and international collaboration between an education professor from Spain and an engineering professor from the USA, we developed a 'Lifelong Learning Competencies for Engineers' program presented to the students in a workshop. This consisted of presentations on lifelong learning competencies and specific recommendations for lifelong learning for engineers as well as an active learning exercise. The workshop was implemented in a senior design course at USD in Spring 2011 with 21 electrical and mechanical engineering students.

The data analysis results show a statistically significant difference in the students' knowledge of lifelong learning competencies after the workshop. In the post-survey, the largest improvement was seen in their knowledge of personal development plans. The students recognized that lifelong learning is important for their future professional development as engineers and their agreement is stronger after the workshop.

The evaluation of the qualitative data from students' responses to open-ended questions confirms that the workshop was beneficial. Although many students did have good knowledge about lifelong learning and professional competencies by the time they are seniors at USD, about a third of respondents showed improvement in their demonstration of this knowledge after the workshop. Also they reported satisfaction with the workshop experience and activities particularly the interactivity and focus on key competencies. Finally, an important measurement of the program's impact was reflected in their portfolio submitted one week after the workshop. 20 of 21 students mentioned the workshop or its contents in their description of achieving the ABET outcome related to lifelong learning.

In summary, the 'Lifelong Learning Competencies for Engineers' program worked well. Not intended as a substitute for wider efforts infused throughout the curriculum, such a workshop could complement other curricular efforts. It is beneficial for students to reflect on their lifelong learning at the end of their undergraduate curriculum as they prepare to enter the workforce where they will continue to use these LLL skills. Other educators in engineering and a variety of fields could adapt this workshop to help educate their students about lifelong learning and how it can be demonstrated. Presenting information as well as an interactive exercise is important. For other fields, we would recommend identifying relevant information specific to the field. We believe that lifelong learning is critical for empowering citizens of the modern global world and that individuals should be responsible for actively planning their own personal and professional development. We hope that this work opens new ways to contribute to training more competent citizens to meet the changing needs of the modern workplace.

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