The Millennium Generation: Are they ready for the Ultra-Low Power challenge?

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***Abstract*— Millennials are a generation of smart young people currently in development at universities and colleges, and entering the workforce. They have several characteristics that could potentially make them the most productive generation ever. On the other hand the concepts of green, sustainability and energy awareness are part of their vocabulary and most of their jobs will have some relation with these terms. This paper relates an attempt to tailor a microcomputers course to be attractive to this generation of students. What we have found is that the traditional teaching formulas have to be adapted and social networking tools adopted to make them appealing to people that do not know a world without internet, wireless communications and social networking.**

I. INTRODUCTION

When teaching a Microcomputers course, among the different challenges encountered one of the most important is to give a quick but comprehensive overview of the concepts and evolution of the microprocessor and microcontroller systems in the last half of the 20th century and almost 10 years into the 21st century to a new emerging generation of students that are joining and preparing to enter the workforce. For this new generation of students denominated “Millennium Generation” “Net Generation”, “Millennials” or “Generation Y” [1-4], the internet has always existed, and research is done using Google and Wikipedia. The information to millennials has to be delivered using the latest audio visually rich technology, they need to be given multi-tasking challenges to be solved using a collaborative approach, they need to be given instant feedback, and at the same time you need as an educator to recognize that they may not see the need or indeed take responsibility for their development or failures.

Not so many years ago, a microprocessor or microcontroller educational system could be implemented on a breadboard and wires; knitted with wire-wrap; or designed on a PCB. Current state of the art calls for surface mounted devices which can make soldering on a PCB a not very practical task and the first two methods are already obsolete. Nowadays, development systems used to teach students come already in the form of educational kits that are applications rich and ready. On top of that, an ultra low-power microcontroller spends most of the time in sleep-mode waiting for an event to occur to wake up capture data, perform calculations, take actions, communicate and then go to sleep; this concept goes against what the textbooks traditionally cover.

Some of the new millennium jobs characteristic is that innovative systems and devices that will be designed and implemented should be energy aware, self sustainable and efficient. This posses an interesting question: “In a university environment: how can we transfer to the millennials all the concepts of classical microprocessor and microcontrollers systems using the latest in multimedia technologies, get the students to perform concurrent tasks while collaborating in teams, offer immediate feedback on their performance while making them responsible for the projects that they get involved in? “

This paper focuses on the current offering and outcomes of a Microcomputers course currently under development at the Computer Engineering Technology department at RIT. The course is taught mostly to second year students on modern power aware devices that break the traditional concepts of always-on devices. The organization of the paper is as follows: In Section II we give an overview of the Millennium generation traits as currently being perceived and how tacit knowledge could be unlocked using social networks. In Section III we analyze the job profile that many of the engineering students will have to match in energy efficiency awareness jobs. In Section IV, we give an overview of the Microcomputers course being taught and how some of the techniques were modified to make them appeal to the millennials. Section V is just a review of concepts that millennials need to be familiar with, and as educators what information could we convey. Finally in Section VI we conclude the paper by summarizing what has been accomplished and suggest some possible changes to the course to make it appealing to students at the same time they get prepared for the future challenges of Ultra-Low Power.

II. THE MILLENNIUM GENERATION

Technology is a central point to most adults today, 13 years ago less than 25% of working adults in the United States accessed the internet, today the numbers have grown to 96% and of those 55% have broadband access at home [5]. Some of the characteristics [2] of the Millennium Generation are: more than 50M in the US and 250M in the developed world; largest generation in the last 50 years; grown up with technology and instant access to information; early technology adopters; less interested in corporate life; demand their technology to be supported in their study/work environment; heavy users of non-traditional media; comfortable with e-learning; require instant feedback.

A. Tacit Knowledge

The Millennium Generation uses technology in a way that has not been used before and this characteristic makes it a tacit workforce [5]. Tacit knowledge as the name implies is “with no words.” The knowledge in a company is based on the information stored in databases, but the largest amount of knowledge is in their employees’ brains. Knowledge and information that is passed from person to person and grows with the company, this is the reason that informal communication is as powerful and sometimes more powerful that written or stored information. In summary, any corporation has information stored in databases as well as in people’s brains. The question is: “how to unlock both?”

The millennium generation has: a strong sense of entitlement; a desire for tailored applications; are team enabled; and want to express their opinions. They expect to be connected to peers and expect to have the same technology available to learn as they have in their personal lives outside the classroom. The millennials want to have access to others’ profiles in order to cooperate and solve problems. This is done by networking and finding the right person with the right information, and with the less amount of effort involved. As stated in [6]: “Tacit knowledge can be unleashed and shared as never before by connecting people ubiquitously through social networking and its closely related partner, collaboration.” So the question is: How can we promote or start tacit knowledge sharing within the classroom?

B. Google and Wikipedia

It is amazing how the millennials use online resources instead of traditional ones. An interesting example is the following: You give the students some material to read and ask them to answer a set of questions. The students rather than looking into the material presented, they cut

and paste the questions to the Google toolbar and look for an immediate solution, there may be hits to Wikipedia that will divert the student to a web page that contains the contributions of one or multiple authors to a particular topic. All this has happened without even looking at the original notes given. If no satisfactory answer is obtained, then they will refer to the originally available material.

The controversy comes when the students question differences in the material presented and what is available on the net. This disagreement is not wrong, it is very healthy to question sources and validity of information, but the problem is whenever there are no valid criteria to argue, such as not reading the original material presented. This can create a conflict in the sense that the student relies more on on-line information to solve all the problems and if that information is dead wrong they could blindly take it as the truth.

III. ENERGY AWARENESS

One characteristic of this new generation is that most of the jobs in engineering will require some kind of green and/or energy awareness skills. One very good example is the new initiative for smart grid developed by the US government. In terms of innovation, it has been endorsed that it will have a similar growth compared to that of the internet. A new set of skills will be required to adapt the workforce to this particular technology. This represents a change in the university curricula to satisfy the requirements for this new technology.

How this does relate with a Microcomputers course? Smart grid in a small context is all about embedded systems, sensor networks, wireless and power line secure communications, smart meters, etc. The main theme is about “embedded”, “secure”, “smart”, and “communications”, this all relates to microcomputers in one way or another. Embedded systems are now everywhere and the connected world relies on these as a new way of living. Another very important area is Medical Electronics in which a system should have some of the following characteristics: ultra-low power, security, robust, reliable, accurate, cost-effective. Throughout the Microcomputers course, the instructor emphasized and gave examples on how to use the available technology to think in terms of energy awareness, making smart products, communicate information using secure techniques, and how to perform computations on demand rather than continuously in order to save power.

Unfortunately on a single course, and with no previous knowledge of microprocessors and microcontroller systems, we were not able to fully teach and cover ultra-low power applications, other than couple laboratory exercises and lectures to show how the microcontroller can enter a sleep state and just wake up whenever it is required, thus saving power and performing computations on-demand. A revised course outline is being developed to include and advanced course to focus more on the microcontroller energy efficient applications which could be the stepping stone for future energy aware innovations.

IV. ULTRA-LOW POWER MICROCOMPUTERS COURSE

This section gives an overview on how some of the course material has been adapted to appeal to current students whose majority belongs to the Millennium Generation. Traditionally the course was being offered focused into general Microprocessors/Microcontrollers knowledge. There were several platforms to be used in the course for example: Atmel-AVR, Freescale-HC12, Microchip-PIC. The platform chosen was the MSP430 from Texas Instruments (TI). The decision was done due to the emphasis that TI has on developing ultra-low power applications for different markets such as smart-meters, medical devices, smart appliances, consumer electronics, etc. On

the other hand TI's level of support to universities has been extremely good and very efficient in their time response. With less than one month notice, TI donated the complete setup for a microcomputers laboratory in terms of education material, development hardware and software, textbook references and offered a vast number of resources available on-line. Students are encouraged to explore these resources available on-line, reference code as well as other material.

What can we define success in terms of product development and reaching time-to market? The answer is reutilization! By reusing hardware, software and creating product differentiation is the key to rapid innovation and product deployment. This is a philosophy that we are currently promoting in our courses.

Also it is worth mentioning that the online learning student community available at RIT is a great platform where most of the social networking tools are already incorporated by providing: course content, drop boxes, grading, quizzes, chats, surveys, class list, e-mail, discussions and calendar. This means that the students are already using an institutional social networking tool environment which is complemented by the different activities described below.

A. Course Material

The course material was based on a textbook, web available notes, copyrighted notes, and Powerpoint course notes. There were several reasons behind the selection of these materials: Students should learn how to reference the material available in a traditional textbook and thus chapter readings as well as homework were assigned from this resource. Since most of the students will go to the internet to access information, some readings were assigned from materials found there and the students were given the link to the original source as well as to have it posted in our internal learning servers. Unfortunately there was not a book available that had all the material required for the course, so the students had access to copyrighted material to complement the lecture. Students should be reminded that it is illegal to make photocopies from books. Lastly the core of the material were Powerpoint generated course notes that were based on the three previously mentioned sources. References to the original material were placed or at least mentioned throughout the slides, so the students would go to the original notes if something was not clear.

The questions for the exams were gathered from the lecture notes, distributed one week in advance such that the students had a reference to solve all the questions before the exams. How many did actually go through the notes and make a good summary? I think the exam grades showed the answer and overall average was around 73.51% and 74.47% for the first and second exams. In section C we describe the methodology for creating and applying the exams.

B. Home Work Assignments and Laboratory Exercises

There were two types of homework assignments and laboratory exercises: Unrelated and related. What I mean is that some homework assignments and laboratory exercises were completely independent of each other, around 50%. The other 50% required the student to solve a particular homework problem by coding and presenting simulation results, while the laboratory exercise showed physically what was coded. One good example is a 16 samples moving average computation, where the students were given 256 signal samples and are supposed to compute a windowed moving average. In simulation they just cared about the final results for each series of 16 samples, but when they went through the lab, they discovered that the original signal was a noisy sine wave and what they have just coded was a very simple low pass filter. In general most of the students liked the example and related the operations performed with a real application.

During the laboratory exercise they were also given a Matlab m code program that generated additional values and by doing a copy & paste from the Matlab output directly to their look up table, they were able to explore different frequencies and noise relationships. These examples complied with the immediate feedback on their work and a real world application.

C. Exams & Quizes

Since this generation requires immediate feedback, many of the short quizzes were given on-line and the students at the end of the quiz knew their scores. The exams were prepared in a similar way but were quite challenging since the first two exams were based on 20 multiple choice questions out of 120 possible answers. The complete sets of questions were posted on-line one week in advance with no answers. The students need to review the material and come with the correct answer and be prepared for a multiple choice answer. On top of that, the 20 questions were random for every student and they were not allowed to go back and forth. This makes it very difficult for somebody to try to obtain the correct answer by waiting until somebody else has the same question and knows the correct answer. The exams were allocated half an hour more than the time allocated if it was held in class. The students had an evening to complete the exam.

In the view of the students, the first exam was fair and no major complaints were observed, so the students by majority decided to have this format for the second exam. Since the material in the first exam was mostly concepts and no programming skills were needed, no extra work was assigned. The second exam included a section, where at the end of the exam they were given a random assembly language programming problem out of 8 different. This triggered a very interesting collaboration case. Traditionally, students work in groups and they select who to work with. For this particular case, they were told that collaboration was acceptable as long as their code was written individually. Students that do not know each other, started to find who had the same problem and started to brainstorm on how to solve it. Almost everybody hurried to finish the multiple choice question section and then started to look for problem partners. The results were good and strong students pulled weak students and the interaction was very good.

D. Local and Remote collaboration

Sometimes when a homework assignment was given and as a vehicle to encouraging students to come up with questions, I had a remote session opened in Adobe Connect to solve questions out of office hours in the evening when students are at home working on their assignments. The intent of this approach was to show students how to execute different parts of the process by sharing my screen and recreating the steps required on-line. All this was in an environment that had a common chat, such that everybody was able to follow the procedure as well as ask questions and obtain answers from me or some other student. Some students were shy and did not want to broadcast their questions and we were able to have a private message exchange, but I was trying to promote for everybody to participate. Did the students take advantage of this technology? Did it result in productivity similar to a corporate environment? The answer was no! I did not have the participation expected, and the real-time exchange of information was not comparable to that of a conference call for business. I was hoping for more interaction but maybe the sole presence of the professor on-line was not very encouraging for participation.

E. Tricks of the Trade

It is interesting how some students use the internet to find solution to the problems presented. One day I found some of the laboratory assembly language on-line after doing a Google search on the topic. That means that a student is posting the code as he works on it to make it available for others as being developed and thus encourage participation.

I also found that when the exam was taken, some people were sharing results on the internet, bust since the questions were out of order, random and you cannot go back and forth, my conclusion is that the students wasted more time posting on-line and hoping for somebody to post the solution on time and to be correct. This is a reflection to what "googling" can give you, you may find that the answer indeed is incorrect but if you do not have much background and/or be critical on the information, it could be the same outcome as throwing a coin.

Some others take the "Musketeer" approach "all for one, one for all" which is a double edge sword. In one instance collaboration is extremely powerful, but on the other hand it can just make a not so strong student hide behind collaborative work. And we were able to detect it by asking students the "how?" and "why?" decisions were taken when similar problem solving approaches were found. Currently with code assignments, it is very simple to run side by side comparisons to find differences and similarities.

V. PREPARING MILLENIALS FOR THE CHALLENGE

Millennials multitask: they can listen to music, while they chat on IM, check their Facebook page, text some friends on their Smartphone, and at the same time they are engaged in studying for the exam. How can we bring all these technologies to the classroom? This is a good question that is being addressed slowly, but we could start bringing some of these technologies and concepts now by exploiting e-learning, remote meetings, social networking, guiding a good research on the internet by showing them sites such as IEEExplore and professional databases available at the university.

New teaching technologies are being introduced and adapted every day to the use of modern communication technologies such as: clickers, social networking, code sharing sites, instant messaging, "tweeting", text messaging, Wikis, web conferencing, and blogging. All these technologies can give you a new perspective of the way this new generation is assimilating and sharing knowledge. At the same time the teaching tools and methods used should prepare the student's transition to the use of industry wide social networking tools such as the use of: Linkedin, Sharepoint, Outlook, Blackberry enterprise communications, conference calls, video-conferencing, desktop sharing, to mention some.

VI. CONCLUSIONS

This paper is just an overview on how the Millennium Generation responded to different types of stimuli during the development of a Microcomputers course. In general there are many areas in the course that need to be redesigned, but my hope is that some of the concepts given as examples on energy efficiency, ultra-low power, reliability, and security gives them an incentive to start digging into these areas which will be vital for years to come.

In the process of teaching and testing, I tried to develop a very fair grading process in which the students were given immediate feedback and knew their progress in the course. Very few students complained about the fairness of the process, and of those who complained were mostly with regards to discrepancies between the written material and what was obtained though search engines. Several social networking techniques were adopted and the student online learning student community website available at RIT is a great social networking tool.

Millennium generation students could be the most productive generation ever and they just need to be presented the information in a format that will appeal to them, the least we can do as educators is modernize ourselves and try to keep the pace with the new workforce that will lead and innovate in the near future.

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