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# The Business Engineering Surgical Technologies (BEST) teaching method: incubating talents for surgical innovation

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**Abstract**

*Introduction* Technological innovation in surgical science and healthcare is vital and calls for close collaboration between engineering and surgery. To meet this objective, BEST was designed as a free sustainable innovative teaching method for young professionals, combining surgery, engineering, and business in a multidisciplinary, high-quality, low-cost, and learning-by-doing philosophy.

*Aims* This paper reviews the initial outcomes of the program and discusses lessons learned and future directions of this innovative educational method.

*Methods* BEST educational method is delivered in two parts: the first component consisting of live streaming or pre-recorded online lectures, with an interdisciplinary profile focused on surgery, engineering, and business. The second component is an annual 5-day on-site course, organized at IRCAD-IHU, France. The program includes workshops in engineering, entrepreneurship team projects, and in-depth hands-on experience in laparoscopy, robotic surgery, interventional radiology, and flexible endoscopy with special emphasis on the interdisciplinary aspect of the training. A panel of surgeons, engineers, well-established entrepreneurs, and scientists assessed the team projects for potential patent application.

*Results* From November 2011 till September 2013, 803 individual and institutional users from 79 different countries attended the online course. In total, 134 young professionals from 32 different countries applied to the onsite course. Sixty participants were selected each year for the onsite course. In addition, five participants were selected for a web-based team. Thirteen provisional patents were filed for the most promising projects.

*Conclusion* BEST proved to be a global talent incubator connecting students to high-quality education despite institutional and economical boundaries. Viable and innovative ideas arose from this revolutionary approach which is likely to spin-off significant technology transfer and lead the way for future interdisciplinary hybrid surgical education programs and career paths.

**Keywords** Surgical innovation · Hybrid surgery · Education · Medical device development

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The BEST educational method was created in 2011 within the premises of Ircad Student Society and the Image-guided Hybrid Surgery Institute (IHU) to meet this new educational need. The BEST educational program was designed to be a sustainable innovative teaching method for young professionals, free of charge combining minimally invasive interventional strategies, engineering, and business in a multidisciplinary, high-quality, low-cost, and learning-by-doing philosophy. Being the first of its kind to also incorporate surgery, endoscopy, and interventional radiology in an integrated fashion for students and residents, in order to establish and nurture an interdisciplinary approach in MIS techniques [1–5]. The flipped class room concept was implemented in order to support this style of learning. This concept combines online and on-site components in which students watch pre-recorded lectures online in their own spare time before entering the institution for group interactions, hence creating greater flexibility and the potential for a more rapid dissemination of medical innovation. [6]. During the course, the participants experienced the philosophy of innovation as well as the latest developments in minimally invasive surgical techniques, medical engineering, med-tech startup principles, and closely interacted with international experts. This paper outlines the structure of the program, describes the outcomes in terms of the participants' interest and satisfaction, the technologies created within the program and future directions of this innovative educational method.

## Materials and methods

### Organization of the event

The entire program was designed focusing on student interests, and the educational standards provided are based on the experts' real life practical experiences. BEST educational method was delivered in two parts: the first component, consisting of online lectures and corresponding evaluations, streamed live, or pre-recorded, with an interdisciplinary profile focused on surgery, engineering, and business. The second component, a yearly 5-day on-site course, organized at IRCAD Institute and the IHU in Strasbourg, France. The on-site training was given in conjunction with knowledge previously acquired from the online component of the course and focused on medical device development. The program included workshops in engineering, entrepreneurship team projects, and in-depth hands-on experience in laparoscopy, robotic surgery, and flexible endoscopy based on simulators, ex vivo, and in vivo models, with special emphasis on the interdisciplinary aspect of the training. The participants attended a broad selection of image-guided surgery workshops, involving various techniques such as the MRI, CT, Zeego, and ultrasound. In addition, the on-site course was broadcasted through a closed web portal for a selected group of students to participate in all course elements. At the end of each on-site training, all teams projects composed of medical, business, and engineering students delivered several prototypes of medical devices, along with a market analysis, regulatory, and business planning.

### Faculty

The faculty from the program included internationally renowned surgeons, gynecologists, gastroenterologists, interventional radiologists, engineers, scientists, and well-established entrepreneurs.

### Broadcasting system

A Cisco (Tandberg) model C90 videoconferencing system was used in combination with a TC4.2.0.260857 software version in a standard configuration, with a transmission rate ranging from 384 kilobits/sec (Kbps) to 6,000 Kbps using the H.264 video encoding format. The required configuration to participate in a live session or to watch a prerecorded lecture was a recent version of Adobe® Flash Player, an Internet browser, and a medium bandwidth (300 Kbps). The faculty had the possibility to record the lecture from their own laptop using Skype, IChat, or an institutional videoconferencing system.

### Participants

Students applied and watched the lectures of the online component after registering to WebSurg.com. For live sessions, students had to register to the sessions in advance, with no limitation in the number of student registrations. Thirty participants were admitted each year to each on-site course, among them 15 medical and 15 engineering/business school young professionals. In addition, five participants were selected for a web-based team, having the opportunity to participate in the on-site course 24–7 while not physically being present at the on-site course. Students were selected based on several criteria: curriculum vitae, cover letter (personal interests in their field of education), participation in all lectures/evaluation on the final comprehensive exams, and monthly assessments related to the lectures.

### Evaluation

The participants' age, gender, country, and the number of attended lectures and visits to the website were registered through a corresponding login account and used to assess the interest of students in the program. Interest of the students in the on-cite course was determined based on the amount of applying students for the on-site course. Furthermore, a day-in day-out questionnaire was provided to the attending students, allowing them to express the satisfaction rate of the training. Participants were asked to express their satisfaction for each component of the course using a Likert-scale (range 1–5). Possible answers were graded very poor, poor, fair, good, and excellent. Each medical device development project created by the participants during the on-site course was further evaluated for potential patent application by a panel of experts. The most promising projects were considered for further development through IHU fundings.

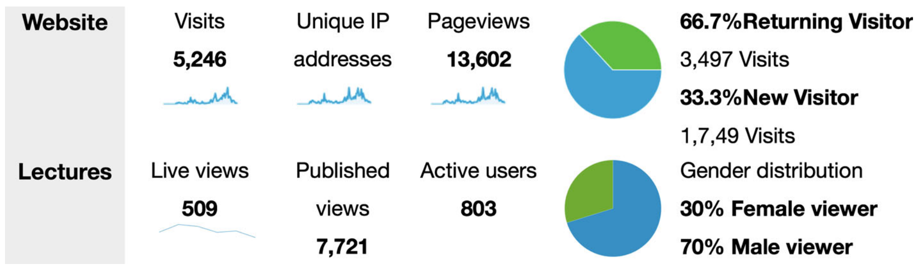


**Fig. 1** This figure displays the amount of unique page views of the website and the lectures (Unique page view/visitor = refers to the number of unique users that access a page—combination of the IP address of the user accessing the page and the cookie file), and the profile of website visitors

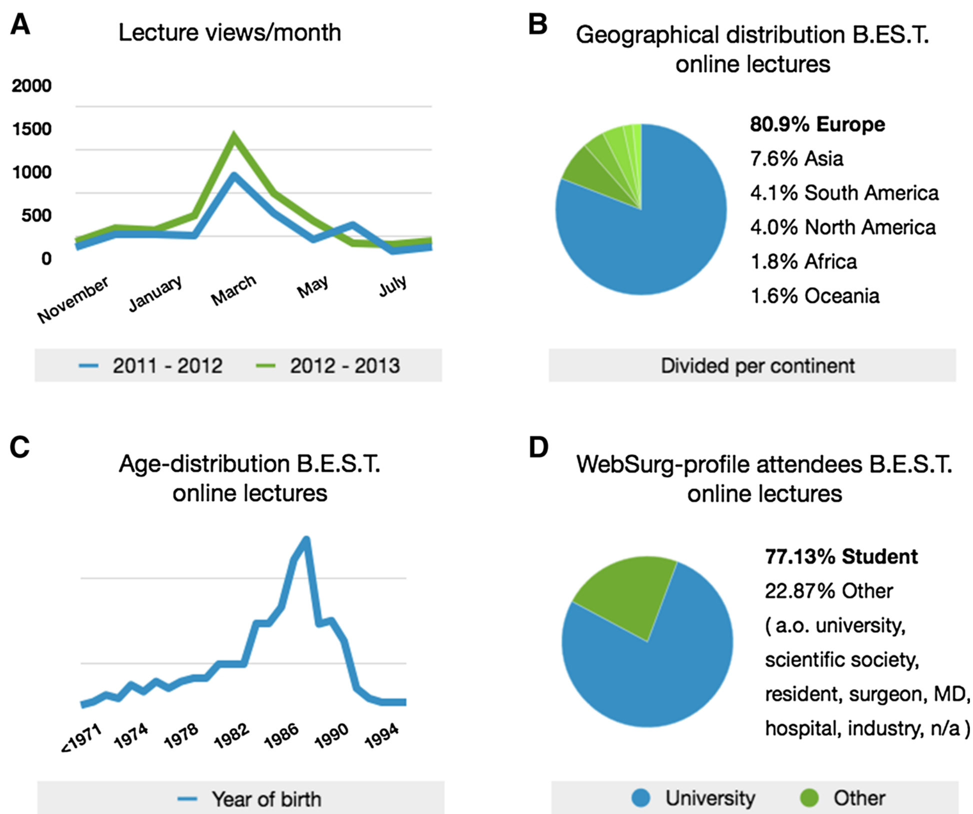


**Fig. 2** **A** The unique lecture views per month over the period 2011–2012 and 2012–2013. **B** The geographical distribution of the online participation. **C** The age distribution of the online participation. **D** The profile of the attendees to online lectures was based on their WebSurg log in accounts

## Results

A) Online program

From November 2011 till September 2013, a total number of 68 lectures were published online, from which six live sessions between 2011 and 2012 and 62 pre-recorded lectures between 2011 and 2013. Eight-hundred-and-three individual and institutional users from 79 different countries (80.9 % Europe, 7.6 % Asia, 4.1 % South America, 4.0 % North America, 1.8 % Africa, and 1.6 % Oceania) attended the online course (mean age 27.1; SD 13.2) and participated to a total of 8,142 lectures (see Figs. 1, 2). Based on the profiles of the login account of attendees, 77.13 % indicated being students and 22.87 % indicated having an another background (a.o. university, scientific society, resident, surgeon, MD, hospital, industry, etc.)

B) On-site program

In total, 134 young professionals (69 % medical, 31 % engineering and/or business background) from 32 different countries (84.9 % Europe, 5.7 % Asia, 4.6 % North America, 2.2 % Africa, 1.3 % South America, and 1.3 % Oceania) applied to participate at the onsite course between 2011 and 2013. Sixty participants (90.0 % Europe, 5.0 % North America, 3.3 % Africa, and 1.66 % Oceania) were selected over the 2 years period to attend the onsite course

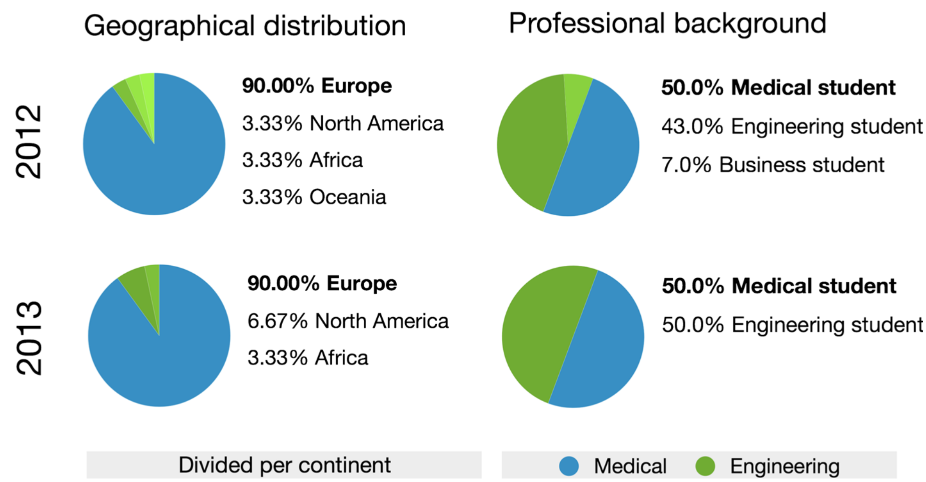


**Fig. 3** The geographical distribution and professional background of the participants for the on-site course between 2012 and 2013

(29 medical, 31 engineering and/or business students) (see Fig. 3). In addition, a web-based team of five participants (3 medical, 2 engineering and/or business students) all from European countries attended the onsite course of 2012–2013.

Educational satisfaction onsite course and provisional patents

Out of 325 surveys conducted during the 5-day onsite course, 100 % was completed. A satisfaction rate of 4.52 (SD 0.13) in 2012 and 4.87 (SD 0.06) in 2013 on a 1–5 Likert-scale satisfaction survey was awarded to the onsite course by the participants (see Fig. 4). Thirteen provisional patents were filed for the most promising projects. Out of these 13 provisional patents, 2 projects were filed for a full patent between 2011 and 2013. In addition, 3 students continued to complete a 3- to 6-month mini-fellowship at the IHU as previously described.

## Discussion

Full immersion in business, engineering, and medicine is an effective educational method for teaching surgical innovation. There are, however, challenges that need to be overcome with this relatively new teaching method. Although it can be very effective and popular with students, the availability of this type of teaching in medical, and specifically surgical innovation, can be limited due to the limited number of opportunities, locations, time commitments, and costs. [7].

At this time of change, with costs playing an important role, education has to adapt to external conditions and adopt popular lower cost technologies [8]. With an educational grant of 40,000 Euros per year, the program was designed to engage students into an innovative, low-cost, and flipped classroom educational strategy. Although having just limited funds, the program has been popular among students, with an increasing trend in program participation over the last 2 years. The majority of the participants who attended the BEST online lectures were from Europe. The program has also reached out to participants in other high and low income countries by offering students the opportunity to attend the program anytime and anywhere completely free of charge and regardless of their professional or geographic background. In addition, what makes BEST unique is the ability to connect faculty members. The program has brought together many renowned experts from major league universities, well-established firms, and specialty practices. Not only does this have the potential to draw both high and low income students to surgical innovation, but it also exposes them to diverse educational content with multidisciplinary and international background [6].

Surgeons are trained to perform continuous situational assessments, decision analysis, and improvisation in preparation for both the challenges and creativity required by real clinical cases. Technological evolution and surgical progress are inextricably linked, where lines between technology and surgery steadily blur, and innovations arise within. Surgeons are innovators, with surgical innovation being fundamental to surgical progress and having significant impact on health policy implementation [9–11]. The question arises then—how do you educate in innovation? In knowing where and how to look, innovation can be systematically managed, but this requires knowledge, ingenuity, and focus [12]. Additionally, it demands a large set of skills that can be enhanced through appropriate education, training, and tools [13]. Currently, young professionals are trained to make assessments and not educated to think in a problem-solving matter. The aim of the BEST program is to stimulate young professionals by offering a system where learning is achieved through the

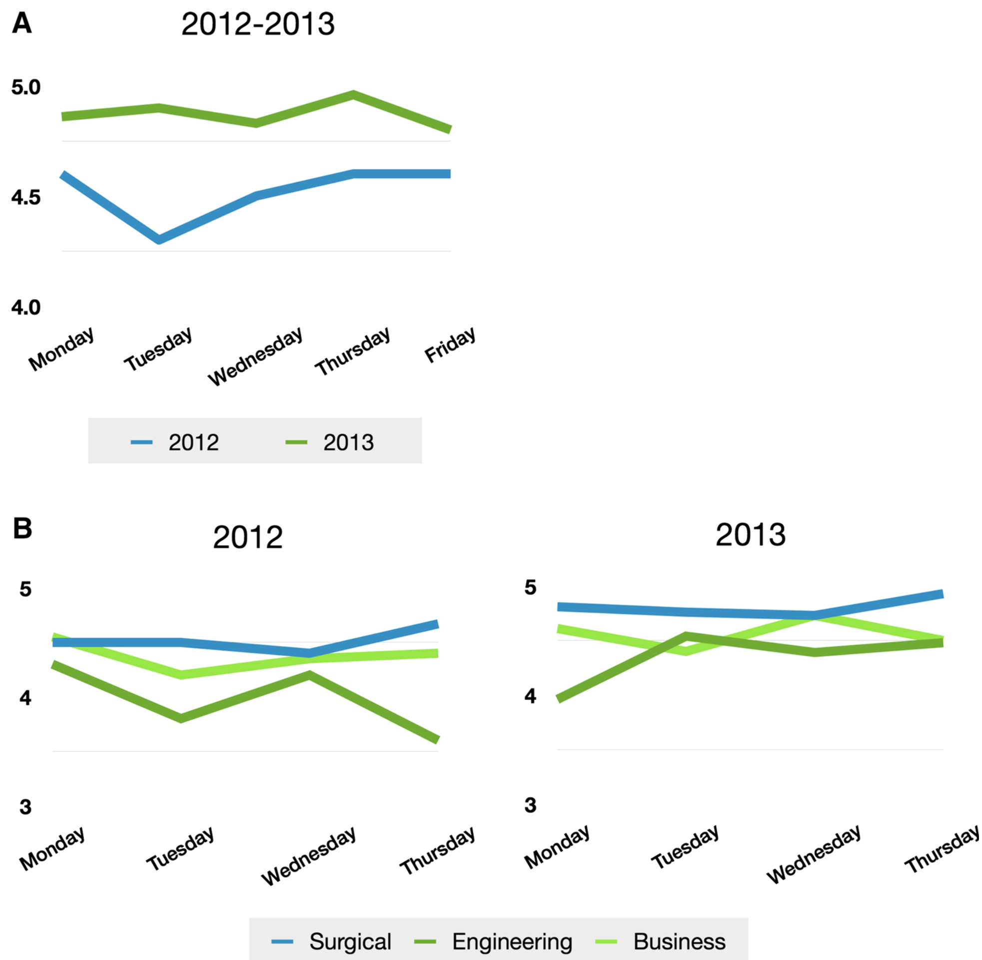


**Fig. 4** **A** The global satisfaction per day of the onsite course between the period of 2012 and 2013. **B** Evaluation per day, per element of the onsite course, divided per year

act of creating, engaging young professionals into a new way of improving minimally invasive strategies. And more particularly, in the light of current economic realities that put pressure on resources, the challenge is to find cost-effective, yet engaging solutions with regards to new technologies for teaching and learning, and to invite students to participate in a formula that engages them to become active collaborators and co-creators, hence involving other students and Faculty in the learning process [8]. The BEST teaching method identified the top notch of young professionals at an early stage of their career, who had great potential within the surgical, business, and engineering disciplines. These top notch young professionals were trained and educated in the cross-disciplinary principles and stimulated to create new patents, start-ups, and industrial collaborations. Creating a new generation of trained innovators equipped to identify opportunities for innovation when others see problems and frustration and initiating changes that may ultimately lead to larger transformations in health care [14]. This vision supports the message of innovation being the seed for translation, benefiting from cross-disciplinary fertilization, and demanding the need for convergence between medical, biomedical engineering, and business education. The convergence of these different fields and establishing effective communication and collaboration among them is essential in the process of innovating [13].

This model of training participants with a medical and engineering background in the full cycle of medical device development was first implemented at the Stanford Biodesign program leading to numerous inventions and related med-tech start-ups over the last decade [7, 15, 16]. Despite tremendous efforts and progress in discovering new clinical niches and developing new devices, significant translational barriers still exist between new discoveries and clinical applications. One essential aspect in the creation of a curriculum that focusses on surgical innovation is to be able to develop a clear view of what is the clinical need, what is needed to realize success, and why the problem is worth solving [13]. Due to lacking practical experiences, young medical professionals and particularly young engineers often possess a high level of theoretical knowledge which they are not able to translate into a clear understanding of healthcare needs. This sometimes asks for taking the road less traveled and to immerse them in the field of medicine and engineering in clinical and practicebased problem identification by providing adequate training to acquire real world surgical skills, such as training them in laparoscopic surgical skills on in vivo and ex vivo models during the institutional courses and tackling challenges.

In addition, the teams during the BEST on-site, composed by medical, engineering, and business students, were challenged to find a solution for a current clinical need in surgery. Throughout the course they attended interactive workshops, outlining the full medical device development cycle, and reviewing different business cases, reasoning why certain products failed or succeeded on the market.

BEST is not only a program that transfers knowledge and educates young professionals in surgical innovation. Moreover, it serves as an incubator. In addition, it serves as an incubator, namely to incubate innovation and education, and to introduce the right players into the field. An important factor contributing to the success of the program has been involving the industry as one of the fields of expertise present during the course and sharing their experience and knowledge. Medical innovation depends on this extensive interaction between universities or institutions and industry [17]. The industry can fund, develop, and implement technological surgical innovations efficiently on a scale that single individuals or institutions could not. Those resources and their expertise to generate marketable products from novel technology and innovation are essential in the process of innovating and indispensable in an educational format educating in surgical innovation [18].

The ultimate goal of the BEST program was to be a sustainable program in surgical innovation. Not only transferring the philosophy of surgical innovation to its students, but also passing the innovation message on to a new crowd, continuing to create and develop new technologies. Consequently, the most talented students are offered two tracks after completion of the BEST on-site program: first, the possibility to join the IHU for a BEST mini-fellowship of 3–6 months to further develop their project and prototype; secondly, students are encouraged to apply for the IHU Strasbourg Innovation fellowship Program (I-SIP) at the IHU during their residency or after completion of their post-graduate education as fellows. This is a unique opportunity for outstanding interventional radiology, surgery, endoscopy or engineering graduates to work in a multidisciplinary team in order to reshape surgical training, be trained in the innovation process associated with the development of image-guided hybrid surgery, and to design the interventional tools of the future.

To conclude, this unique way of shaping and delivering education raises the opportunity to create a whole new generation in hybrid specialists, which is self-sustainable and constantly renewing itself. The BEST educational program connected students and faculty despite geographical and structural boundaries, gave young upcoming talents and the opportunity to progressively learn the skills necessary to smoothly navigate through minimally invasive surgery, engineering, and business, and to write their own surgical strategy or business plan. Viable and innovative ideas arose from this revolutionary approach which is likely to spin-off significant technology transfer and lead the way for future interdisciplinary hybrid surgical education programs and career paths.

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