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RESEARCH ARTICLE

Getting ready for Generation Z students - considerations on 3D printing curriculum

Preparando a los estudiantes para la Generación Z: consideraciones sobre el currículo de impresión 3D

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Summary

As there is a worldwide adoption of 3D printing (3DP) in many activity areas, formal education becomes mandatory for acquiring theoretical knowledge and hands-on skills for an efficient use, for bringing real contributions to the development of this technology and its applications. Truly digitally natives, Gen Z students are now entering higher forms of education. They are trained by Gen X and early Gen Y professors who should be able to cope not only with students' different set of skills and mind-set, but also, in case of 3D printing, with the media overexposure of this technology and, consequently, with a tendency of fast acquiring shallow knowledge and being auto-sufficient with this. In this context, our research examines the challenges and implications raised by 3DP curriculum aspects, providing a series of considerations and analyses based on literature review and on a long experience of teaching this topic in an engineering environment. Results of a survey aimed to understand Gen Z Romanian students' expectations on learning and teaching 3DP are also presented. We agree the idea that teaching should be adapted to student prior knowledge, not being practical and efficient to customize it to student trait. In the same time, we consider that knowing new generation characteristics, learning habits and preferences, as a group, can definitely support teachers in choosing the right tools and methods so that to improve correct content delivery and to ensure that this content efficiently reaches audience.

Keywords: 3D Printing; Engineering; Curriculum; Education; Gen Y; Gen Z.

Resumen

Debido a que en todo el mundo se ha adoptado la impresión 3D (3DP) en muchas áreas de actividades, la educación formal se ha convertido en una solución obligatoria para adquirir el conocimiento teórico y a las habilidades prácticas para un uso eficiente, para brindar contribuciones reales al desarrollo de esta tecnología y sus aplicaciones. Los verdaderos nativos digitales, los estudiantes de la generación Z acceden ahora a la universidad. Los universitarios de la Generación Z reciben instrucción por parte de profesores que pertenecen a la Generación X y a los primeros representantes de la Generación Y. Estos profesores tienen que hacer frente al diferente conjunto de habilidades y mentalidades de la nueva generación de estudiantes, al igual que, en el caso de la impresión 3D, a una sobreexposición mediática de esta tecnología que genera una tendencia cada vez mayor de los jóvenes a la adquisición rápida de conocimientos superficiales y a la autosuficiencia. En este contexto, nuestras investigaciones examinan los retos y las implicaciones inherentes a los aspectos curriculares de la impresión 3D, ofreciendo una serie de consideraciones y análisis basados en el estudio de la literatura y en una larga experiencia en la enseñanza de esta materia en el ámbito de la ingeniería. Se presentaron también los resultados de un estudio que persigue comprender las expectativas de los estudiantes de la Generación Z de Rumania en relación con el aprendizaje y la enseñanza de la impresión 3D. Estamos de acuerdo con la idea de que la enseñanza debe ser adaptada a los conocimientos anteriores del estudiante, pues la personalización de esta en función de los rasgos de los alumnos no resulta ni práctica ni eficaz. Al mismo tiempo, consideramos que el conocimiento de las características de las nuevas generaciones, de sus hábitos de estudio y de sus preferencias como grupo, pueden, sin lugar a duda, orientar a los profesores a la hora de elegir las herramientas y los métodos adecuados en aras de mejorar la transmisión correcta del contenido y de garantizar que este llegue eficazmente a la audiencia.

Palabras clave: Impresión 3D; Ingeniería; Currículo; Educación; Gen Y; Gen Z.

Introduction

Since its launch at the end of the '80, many names have been used to designate what is now considered a "disruptive technology" (Manyika, Chui, Buglin, Dobbs, Bison & Mars, 2013): Additive Manufacturing (AM) – the standardized name (ASTM 52900 2015) indicating the manufacturing approach of building objects by superposing layers of materials; 3D Printing (3DP)

– the most used term, colloquial, expressing an analogy with inkjet paper printing, although it is actually referring to one process – Fused Deposition Modelling (FDM); Rapid Prototyping – the name indicating one major application of this technology, i.e. manufacturing prototypes directly ("rapid") from the 3D virtual models; Solid Freeform Fabrication; Layer-by-layer Manufacturing; etc.

Why this technology, initially viewed as too speculative by industry, became in the last years the protagonist of hype? Several possible explanations could include:

- A large and continuously increasing number of applications: engineering, medicine, military, entertainment, architecture, fashion, art, education, etc. Media is presenting especially the success stories, with a special focus on the spectacular ones, emphasizing only the advantages of this technology;
- Affordability: some FDM (or FFF – Fused Filament Fabrication) machines can be acquired (even from supermarkets) by anyone with as less as 200 dollars for a kit, which is not at all the case for the other manufacturing technologies machines;
- Accessibility: 3DP concept is not difficult to understand and some results (i.e. objects) can be obtained with little technical knowledge just by following a simple set of instructions/steps;
- Design freedom: 3D prints with complex geometries can be manufactured, which means obtaining products with reduced weights and improved functionality or built directly as an assembly (Cuellar, Smit, Plettenburg, & Zadpoor, 2018). This characteristic allows manufacturing objects for industry (Milewski, 2017), but also spectacular/"show off" objects;
- Intellectual property is not a fully regulated issue even if AM service providers or online repositories owners, for instance, are trying to take measures to limit the unfair uses of the digital information leading to physical objects. As it is impossible to monitor what people are printing at home, copying items without permission is considered appealing for some, thus contributing to 3DP popularity.

It is interesting also to note that AM important advantages such as simplified business process model, manufacturing parts and spare parts on demand, straightforward products or components customization, simplified logistics, suitability for local production and small-scale production (Manyika et al., 2013) are less known to the large audience and, consequently, less discussed, yet they are very important for industry.

This technology should not and cannot be reduced to its spectacular applications or its use by hobbyists. It is not only about buying a 3D printer and printing at home toys or other objects downloaded from online repositories or reversed engineered. Yearly, hundreds of scientific articles and patents are published, AM process parameters are studied and optimized, new materials are adapted to this technology and research projects are financed (European Commission Executive Agency for Small and Medium-Sized, 2016). AM should be seen beyond the publicity and beyond the myths (Roca, Vaishnav, Mendonca & Granger, 2017). This is a paradox about AM: it is both an overestimated and an underestimated technology.

Educators should put AM/3DP in the right place among the other technologies. Hence, the authors' opinion is that formal, in-depth education is a must in this field considering the described context and the importance of the technology. This is particularly necessary in higher education aiming to train not only technology users, but also technology developers.

The paper is discussing 3DP curriculums approaches for students engineering training, trying to find out if teachers are considering in delivering information not only the content, but also the characteristics and learning styles of the new generation of students. Gen Y and Gen Z students are now enrolled in higher education forms, and they are trained mostly by Gen X professors. As presented in the theoretical background section, there are differences between the generations forming the current group of students (Monaco & Martin, 2007; Jonas-Dwyer & Pospisil, 2004; DiLullo, 2015), which impose applying different educational approaches. There are also studies analysing the challenges posed by Gen Z to Gen Y to engineering teachers, such as (Correia & Bozzuti, 2017). Overall, analysts consider that there should be modifications in the educational paradigm required by Gen Z students. Among others, these changes refer to the use of collaborative learning tools, the development of more creative content and evidence-based practice, the use of hands-on activities, as well as the provision of permanent feedback and a more personal contact with teacher. In the same time, the teaching methods should also encourage students to study this technology in detail and help them develop their critical thinking and reasoning on 3DP processes. Both theoretical and practical knowledge are mandatory in 3DP education. Lectures and lab works should be interesting and engaging but not meant to entertain. The contents of several syllabuses are also discussed in the paper, while their common learning objectives and learning outcomes are listed. Whether these curriculums are shaped based on Gen Y and Gen Z characteristics is also an investigated aspect. Our own experience in designing a 3DP curriculum is presented, along the results of a six years survey aimed to understand students' expectations on learning and teaching this technology. The final section summarizes our conclusions on the 3DP curriculum and methods of teaching adapted to Gen Z students.

Theoretical background.

Teaching Gen Y and Gen Z.

It is often believed that generations, like humans, have personalities, and Gen Y or Millennials (born between 1985 and 1994) are seen to have created their own personality: confident, self-expressive, liberal, optimistic and open to changing the world. Some of the characteristics that have been attributed to Millennials are the following: the absorption of technology in their everyday lives, an unquestionable trust in the future, which can serve as both an opportunity for development, but also a risk (for example under the form of incapacity to assume some social, ethical or scientific responsibilities) and fear of responsibility (Barnes and Noble College 2015). The subsequent generation has been called many names, including Gen Z, "Sharing Generation", "All Technology All Time" generation, and "Born Digital" (Barnes & Noble, 2015), iGeneration, iMillennials or post-Millennials generation. It includes the generation born from 1995 onwards. Gen Z are born in the digital era, being truly digitally native, with omnipresent connectivity, global information and 24/7 news cycles. It is often said that they have a "Fear of Being Offline – FOBO". Members of both generations are now following educational programs worldwide, and educators are faced with the challenge of obtaining similar educational outcome from generations that have different characteristics and learning styles.

There has been more research on how Gen Y and Gen Z should be approached in the workplace than research on how they should be approached in the classroom, although we could most reliably apply many of the findings from the workplace settings to the educational ones. Research has showed that often instructors have low knowledge about the characteristics of this generation (Correia & Bozutti 2017). It is not yet thoroughly analysed the differences in learning styles for each of these two generations. Educators, based on their practical class experience, tend to consider that these differences exist, but a rigorous analysis is still missing. Data on Gen Z learning habits is still scarce considering that this generation is just yet entering high schools and universities. However, a well-documented fact however is that in time more and more Millennials had access to the Internet, and certainly a larger share of their generation has had internet access in comparison with their predecessors (PewResearchCenter, 2018). However, Gen Z grew up with already existing social media, smartphones and information accessible with one click, taking these things for granted. This is one reason why regarding the learning style, there are differences between the two generations in the way information is processed. The teaching support for Millennials combines both the traditional educational model and the new digital techniques, while for Gen Z the preference goes to digital models and techniques - Virtual Reality, Augmented Reality etc. Millennials would rather communicate via text or voice, while Generation Z prefers

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using video communication. (Thomas, 2011). Members of Generation Z are pragmatic, multi-taskers, but have short attention spans (Corbisiero and Ruspini, 2018). The learning style for the Millennials generation must respond to the rapidity with which information should be presented in order to capture their attention, considering the shorter attention span and easily distracted behaviour. Gen Z will explore educational alternatives. They will follow on-demand or just-in-time learning solutions such as YouTube tutorials or will look for employers who offer workplace training and development. As noted in (Swanzen, 2018; Shatto & Erwin, 2016), Gen Z prefers to learn by observing and doing, rather than by listening and reading, more than the other generations.

The challenge we should be answering, rather as educators and not only as trainers of professional skills and soft skills, is to understand the expectations and preferences of new generation in order to support selecting the right tools and methods so that content efficiently reach them. As (Correia & Bozzuti, 2017) noted, "the instructor will need to know their strengths, weaknesses, challenges, and interests". Young people want to be well prepared in order to maximize their potential, alleviate the inevitable challenges that exist between transnational generations, and capitalize on cognitive diversity through a generational workforce. The only constant we can count on is the rapid change of society due to the technological evolution, and thus the way in which the educational paradigm should evolve.

In the following we will present the approach to teaching Millennials and Gen Z, taken in an AM technology course at University Politehnica of Bucharest (UPB), the largest and the oldest technical university in Romania. We will show how through the answers given by students in surveys about the way they would like the educational process to be, confirm the characteristics of the Gen Z presented here above. The following sections also present suggestions on how the teaching process should be adapted in order to meet the specificity of Gen Z engineering students, as a group.

Literature review on 3D printing curriculums.

Open-ended questions surveys conducted at the beginning of the course on AM technology, between 2011 and 2016, showed that for 89 master students out of 112, the term "3D Printing" is familiar. However, only five students were actually able to give relevant information on what this technology is about (see also "familiarity" concept in (Willingham, 2003)). These five students had direct contact with 3D printers. The others just heard about it or read news on 3DP applications. Thus, superficial knowledge seems to be quite common. Besides, information on other AM processes than FDM or detailed knowledge on FDM (such as part orientation influence over cost and time, mechanical behaviour, support structure or surface quality; STL file correction; relationship between part mechanical properties and process parameters; etc.) were not known by any of the five students. It is worth mentioning that similar surveys on 105 students (2001-2005) from the same faculty showed than none of them knew anything about this technology before attending the course. From the same perspective, in (Paudel & Kalla, 2016) is noted that students are familiar with the term "3D Printing" and not with "Additive Manufacturing". They also observed that "those students who were familiar with the technology and had some experience working with FDM Printers possess some technical knowledge, which was mostly limited within the FDM technology".

There is an overall interest of using 3DP in education. Examples and case studies of how 3D prints are used for facilitating the educational process and the understanding of different concepts are reviewed and analysed by different authors, for different fields and levels of education (Ford & Minshall, 2017; Vandevelde, Wyffels & Ciocci, 2016; Huang & Ming, 2014).

Obviously, attention is also paid to the education in 3DP, the subject of interest for this paper. 3D printing maker education is developed for schools (Nemorin, 2016), in universities (Ford & Minshall, 2017; Despeisse & Minshall, 2017; Williams & Seepersad, 2012; Harvey, 2016; Diegel, Nordin, & Motte, 2018; Go & Hart, 2016; Radharamanan, 2017), by AM producers (Stratasys, 2018; EOS, 2018). Free online 3DP courses are also available (Training in 3D Printing to foster EU innovation and creativity, 2018) and trainings for professionals are organized on the same subject (MIT Professional Education, 2018; Assuncao, Silva & Pei, 2018).

Studies such as (Ford & Minshall, 2017) present reviews on how and where 3DP is used, a non-exhaustive review of AM education programs is also presented in (Despeisse & Minshall, 2017). The authors used the information as basis for establishing a summary of AM courses topics and activities, topics not covered, as well as a summary of skills for AM, and recommendations for training. The small number of AM programs available is noted, but also that "AM is not systematically taught in design and engineering curricula within universities". A similar observation could be found in (Huang & Ming 2014): "there is still no readily applicable, proven model for AM education and training".

Further, several papers presenting details on courses subjects, educational approach, evaluations methods or students feedback are analysed. In Williams & Seepersad (2012) the AM course taught at University of Texas at Austin and Virginia Tech at undergraduate/graduate level is presented. It includes topics on AM fundamentals, AM technologies and systems analysis, design for AM and AM future. Students projects represent 12.5% of the course content. Problem-based learning (PBL) and project-based learning (PjBL) are the main pedagogical approaches used. PjBL paradigm and group assignments are applied also for the final year engineering students from the University of Wollongong, Australia in the Introduction to AM course (Harvey, 2016). The covered topics are introduction and fundamental principles, processes, design for AM, software for AM, AM applications and future directions. CAD knowledge is a prerequisite. Measured satisfaction with the course is 90%, students (n=45) appreciating the teaching method used and the fact that theoretical knowledge is applied to tangible models. Authors also mentioned that the concepts on FDM process were easy to understand, but this was not the case for vat photopolymerization process and its specific process parameters. Other papers on the use of PjBL are presented in (Ford & Minshall, 2017), which also reviews several studies in which 3DP is used as a tool or learning facilitator in developing project for engineering students.

In (Paudel & Kalla, 2016) the AM course from Metropolitan State University of Denver is discussed: detailed lectures and labs contents, learning outcomes, assessment methods, samples of students' projects and final grades distribution. An interesting observation made by authors is that "students are either very excited about AM technology or quite sceptical". This again demonstrates the need to correctly position the technology in students' minds. A sample curriculum of Design for AM at Lund University can also be found in a new book on AM training and education programs (Diegel et al., 2018). Descriptions of topics and proposed exercises are presented. MIT's 15 weeks course for graduates and advanced undergraduates is noted in (Go & Hart, 2016). FDM, SLA and SLS/SLM processes are discussed 2h each during lectures. During lab sessions, groups of students operate FDM and SLA machines, observe and discuss processes capabilities and process parameters, analyse manufactured parts characteristics, etc.

The analysed 3DP curriculums do not explicitly mention that they are developed not only for achieving the learning outcomes, but also based on current students' characteristics. However, their examination showed a clear focus on PjBL, on using visual aids (videos, schematics and, of course, a large variety of tangible objects) for engaging students attention and facilitating active learning, on developing creative projects, etc. All these can also be found in literature as recommendations for teaching Gen Z students (Swanzen, 2018; Correia & Bozutti, 2017, Moore, Jones & Frazier, 2017).

Synthetizing, the key learning objectives of all these courses is to teach students the fundamentals of AM technology, typical manufacturing flow, type of processes and materials, to present AM applications by case studies and examples in different fields, and to provide students hands-on experience in designing for AM and using 3D printers. The learning outcomes are

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focused both on theoretical aspects and practical skills and generally include: understanding the specificity, advantages and limitations of AM technology, understanding the differences between different AM processes, knowing several AM applications in different fields, demonstrate a complete AM flow, knowing how to design parts and assemblies for AM, knowing software for AM, knowing the main components of a 3D printer, knowing process parameters, understanding the causes of defects or errors in 3DP, be able to calibrate and operate a 3D printer and to post-process parts. All courses are using PjBL for achieving these goals and for develop students' capability to analyse, to reason, to assess, to explain results and to propose solutions or improvements.

Although not explicitly connecting the content delivery methods with the characteristics of new generation, it can be observed that teachers are aware of the necessity to adapt to students preferences and characteristics, especially to those related to maintain students focus by blending theoretical knowledge with practice, by using tangible examples and by engage them in collaborative work.

Method

A course on Additive Manufacturing is taught at UPB-IMST for first year master students. The course is 14 weeks long, with 2h of lecturers and 2h of lab work each week, organized as follows: AM fundamentals (historical perspective, working principle, definition, advantages and limitations, STL) – 4h, AM processes (classifications, standardized processes, systems, process parameters materials) – 8h, benchmarking in AM (examples, discussions) – 2h, FDM process (process parameters, process parameter influence over mechanical properties, defects, software solutions for slicing, support structures, post-processing, materials, RepRap) – 8h, design for 3DP – 2h, examples of applications – 4h. Lectures embed videos, schematics and illustrations and encourage free discussions. Collections of parts, assemblies and previously developed research or students projects are presented during lectures and labs. During labs, students design or redesign parts (3D CAD knowledge is a prerequisite) and assemblies for 3DP and they are taught to operate the machines and learn about 3D printers components, correct STL files, experiment with different process parameters and building orientations, work in groups to assignments. In some years, students were also asked to write and present a short essay on AM topics, agreed with the professor.

The course was initially taught with a clearer demarcation between lectures (theoretical aspects) and practical activities (the first lecture was in 2001). However, as time passed, based on students' feedbacks and by analysing their behaviour and implication during classes, the shift was made towards active learning. Flipped classes model was used last semester during two lab works and the results looked promising. Hopefully, 3DP easily allows mixing theory and practice and making teaching process interesting and creative.

In the 2014-2017 period, 58 students voluntarily participated to a closed question survey aimed at assessing students' opinion on how learning and teaching should be done in 3DP field. Free comments could be added by students at their choice. The following questions were asked:

Q1. *Would you prefer to learn 3D Printing by…?*
Q2. *Which tools are better for teaching 3D Printing?*
Q3. *During individual study, how difficult was it to filter the online information?*
Q4. *Did you type messages or surf the web during lecturers?*
Q5. *What should be the ratio between theory and practice for 3D Printing engineering education?*
Q6. *Should 3D Printing be taught in the freshman/ 2nd/3rd …. year?*

Results

The purpose of ***Q1*** and ***Q2*** was to investigate students' preferred method of learning in order to adapt the teaching method accordingly. As teaching tool (Q2) working on individual projects and class discussions were preferred. It was noticed that each year the number of students who prefer individual projects instead on group projects slowly, but steadily increased. This observation can be also found in the literature comparing generations behaviours, specialists' explanation being that the Gen Z in comparison to Millennials show more individualism, despite the high interest in social networks. In line with the results of Thomas (2011) students in our sample value learning by watching and doing, and this is why they preferred individual projects.

Without reasoning in stereotypes, the answer to ***Q1*** and ***Q2*,** as presented in Figure 1 and Figure 2**,** reflect the trend of Millennials and Gen Z to prefer learning by examples and referring visual teaching in the form of videos. We expected students not to be happy about reading an article at home, however we were surprised by their opposition to this teaching approach as reflected by high completely disagree and disagree scores. It would seem that the investigated students heavily prefer to acquire knowledge as fast as possible and with as little reasoning effort as possible – wanting already synthetized information, "the essential".

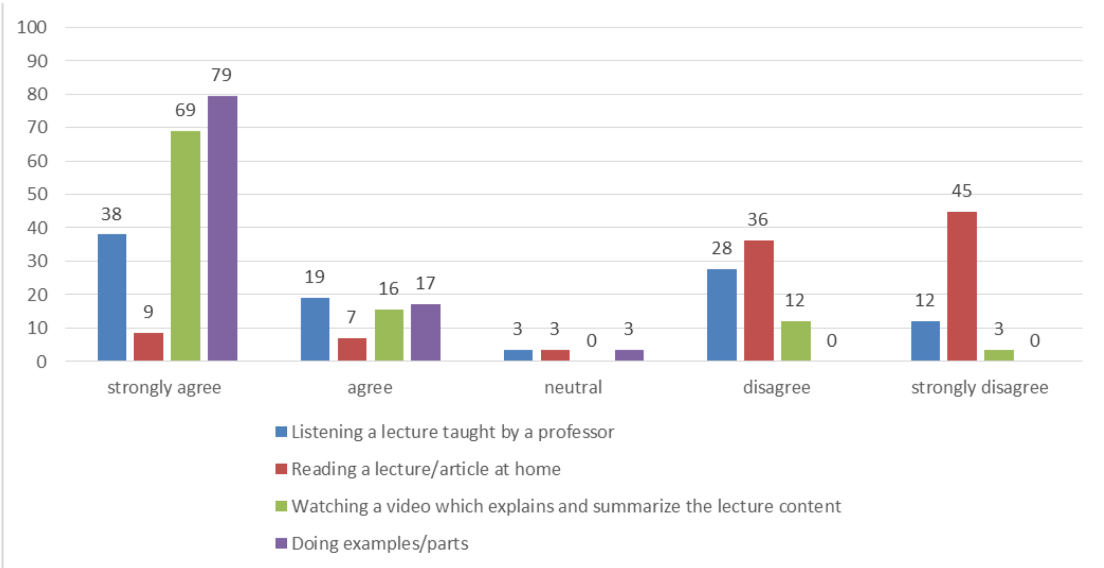

Figure 1. Would you prefer to learn 3D printing by…

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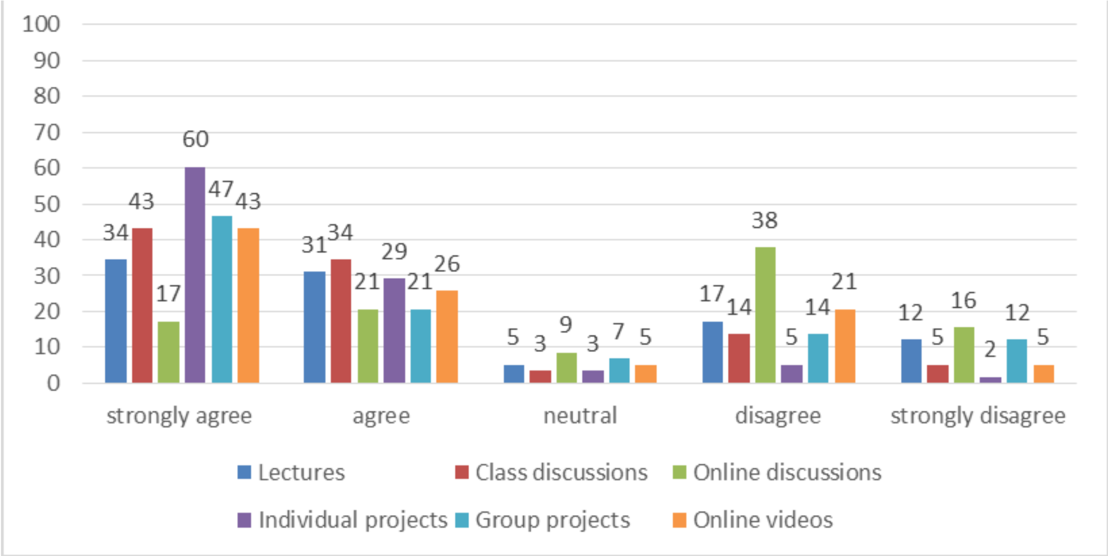

Figure 2. Which tools are better for teaching 3D Printing?

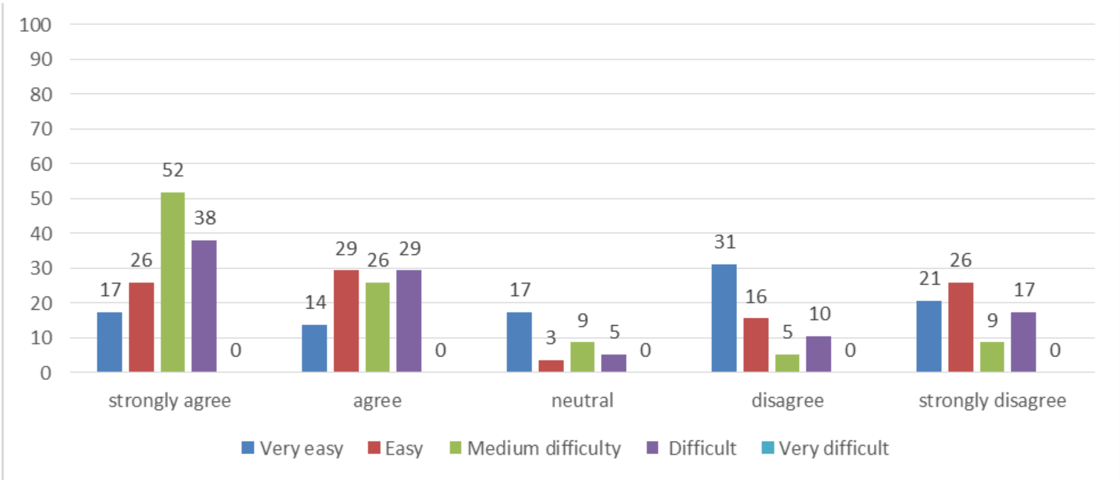

Figure 3. During individual study, how difficult was it to filter the online information?

Q3 (Figure 3) was asked for investigating students' capability to find and filter relevant information on 3DP using Internet. Despite their almost permanent presence online, in the years with essay presentations, students showed an inability to separate relevant and irrelevant information and to question sources. Most of the time, they accept the first ten or maximum twenty searching results provided by Google. Moreover, observing students Internet searching and filtering methods, it was noticed that Images and Videos options on Google were used for searching 3DP applications and cases studies, and only afterwards the option providing text results. When asked to go deeper into the matter, they found it difficult to filter the information. However, providing them the necessary support, the final results (short essays) on their work were good (average mark of 8.4/10).

Q4 was used as a modality to assess if the lectures were interesting and challenging enough to stop them using the smartphones during lectures for non-lecture related activities. 61% of students openly admitted to having typed messages or surf the web during lectures. However, some students commented that sometimes they look on Google for terms they did not understand (instead of asking the professor), while some said they can do more than two things at once, that is paying attention to lectures and typing message not related to the course. It seems that there is a myth of the new generations that they can be multitasking. This is an opinion we do not share, what students call multitasking being in fact a fast switch between tasks, diminishing all tasks efficiency and reducing memory ability to recover the data on these tasks after a medium period of time. During the surveyed period, changes were made on lectures format. More schematics, drawings, illustrations and videos were used. Some theoretical notions were presented also visually, and two Pecha Kucha presentations were given. It was observed that during Pecha Kucha presentations students did not use smartphones. Questions asked after the new presentations did not show a faster understanding of the theoretical notions taught. However, during recaps, students were able to remember faster the information from these lectures in comparison to traditionally taught lectures.

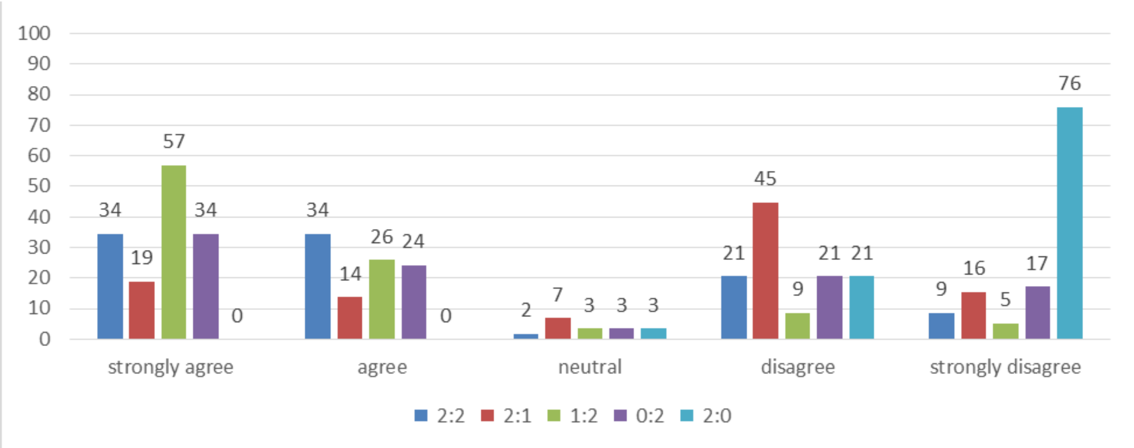

Figure 4. What should be the ratio between theory and practice for 3D Printing engineering education?

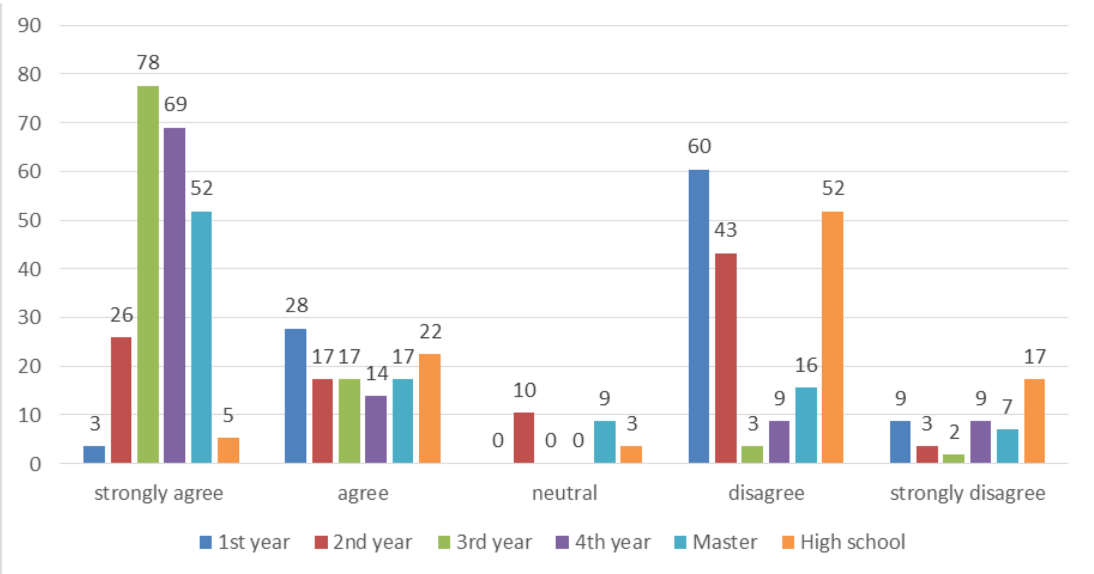

Figure 5. Should 3D Printing be taught in the freshman/ 2nd/3rd…. year?

The purpose of ***Q5*** was to investigate if students prefer more theory or more practice (theory: practice) and as a tool to verify the answers coherence in relation to Q1. As shown in Figure 4, students clearly prefer more practical activities.

Q6 investigates students' opinion regarding the difficulty of the subject (asking students to think if he/she could manage the information at a younger age), as well as opportunity to have

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knowledge on 3DP which can be used for other courses. Regarding this question, the majority of Romanian students considered the topics unsuitable for high school pupils (Figure 5). This comes in contradiction with the trend of teaching 3DP in STEM education in U.S.A., for instance. Students also indicated the preference to study 3DP in their third year of study, comments indicating the value of using tangible 3D prints in other technical disciplines (such as robotics, mechanisms, product design).

The last two questions were also asked to other 105 students from the same faculty in the period 2000-2004. Their options then were towards more balance between theory and practice, 2:2 (2h of course, 2h of lab per week) being preferred by 62% by respondents (8% had no opinion on the matter). On Q6, these 2000-2004 students answered in favour of studying AM technology in their first semester of master studies (65%, no opinion: 12%).

Discussion

Literature (Klein, 2003; Lalley & Gentile, 2009; Willingham, 2003) discusses the effectiveness of providing individualized instruction based on learners' learning styles, types of intelligence, personalities or abilities, showing there is no clear evidence that "style to instruction improves achievement" (Lalley & Gentile, 2009), that "cognitive resources interact with but do not correspond to the categories of curricular representations" (Klein, 2003) and that "teachers should focus on the content's best modality… *modality matters in the same way for all students*" (Willingham, 2005). (Lalley & Gentile, 2009) consider that it incorrect "that instruction should be adapted to learners' styles", proposing to adapt it to student prior knowledge. Agreeing that it is not practical and efficient to customize teaching to student trait, we also consider that knowing the characteristics, learning habits and preferences of the new generation, as a group, can definitely support teachers in choosing the right tools and methods so that content efficiently reach audience.

Our survey results showed students clear preferences towards more practical, interactive, visual learning activities, more digitized learning experiences, more prove of theory applications in practice, as well as a much faster knowledge transfer from the trainer. They also want to be engaged in the learning process and not to be passive information receivers. A (too) short attention span, multitasking behaviour, lack of critical thinking represent as well challenges for educators.

The survey also showed students difficulty in filtering internet information on 3DP and finding reliable sources, and also the reticence to study at home scientific articles. We believe that this last observation can be explained by the characteristics of Romanian secondary and high school levels of instructions which, unfortunately, provide too much info processed by teachers detrimental to through individual study based on a diversity of theoretical resources.

There has been considerable research on what engineering education should include and how educational outcomes should be met. Many universities worldwide have implemented complex approaches to developing not only the technical skills of their students, but also the professional/"soft" ones (Shuman, Besterfield-Sacre & McGourty, 2005). There has been less research though on *how* to teach Gen Y and Gen Z. Examples of research on Millennials education are (Roberts, Newman & Schwartzstein, 2012; Meister & Willyerd, 2010).

Not only the new generations' demands, learning interests and habits, but also the 3DP hype context should be taken into account and tackled by professors. They should constantly and creatively adapt the teaching methodologies, and in the same time they have to face 3DP myths and media overexposure for positioning this technology in its right place among the other manufacturing technologies. It is also important to develop curriculums to ensure that the learning objectives and acquired skills are as similar as possible worldwide, and that students will have a correct understanding of the technology capabilities and range of applications. We pled for AM formal education with teaching methods adapted to new learners' characteristics so that to support them to be innovative, engaged and interested to acquire both practical and theoretical knowledge. The danger that should proactively be avoided refers to not letting superficial knowledge be considered as suffice by the new learners who can see from an early age that they can get prints without having comprehensive information in the field.

Some suggestions can be made based on the research presented in this article. These could be also applied to other subjects or levels of education. The most important, in our opinion, is to consider the characteristics of the new generations, but not to make compromises in teaching them less in-depth knowledge on the grounds that they do not prefer it. Educators should instead dress-up this information into more appealing forms and incorporate the technologies and devices so familiar among Gen Z. Schematics, charts, videos, Pecha Kutcha presentations, flipped classes, etc. could also be embedded into more 'traditional' lectures based on PowerPoint presentations. Hopefully, tasks and project-oriented activities are easy to implement when teaching 3DP. Educators are advised to interact more with the new generation of students, start discussions during lectures, provide shorter feedback cycles and incorporate practical activities in lecturers. In the teaching, maybe educators should make more use of YouTube videos to explain concepts and talk more using images.

Another suggestion is that educators should demonstrate students that accessing first results on a Google search is not enough. Educators should help students identify reliable sources and ask students to filter and critical analyse the information.

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