Peter in the Cloud of Education

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ABSTRACT: This paper presents the experience of a virtual student named Peter concerning various cloud computing services offered by the school where he is currently a freshman. The paper introduces and compares the differences between the traditional Plato's classroom and today's new classrooms powered by novel technologies. In the foreword, we present the milestones of cloud computing in education and research with particular attention focused on services currently available at the faculty as seen from Peter's perspective. The paper also announces further system integration of several currently available services and the intention to extend cloud services from faculty to university level. Such ambitious shift should employ all the benefits, and at the same time overcome many challenges originating from the different aspects of cloud services. Therefore, it is crucial to standardise education in line with many everyday activities.

KEYWORDS: Cloud storage, e-Learning, Social networking, System integration

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1 Introduction

Peter is a young and ambitious student who has always been attracted by information and communications technology. During his middle and high school years, Peter has successfully participated in many computing competitions, including International Olympiads in Informatics (http://www.ioinformatics.org). Apart from his endless fascination with new technologies, he also knows that in the modern era it is crucial to learn and acquire new knowledge in order to survive and progress in the present-day world. Peter learned that the increased demand for learning entailed that the educational process should have the most important role. However, Peter is aware that although technology and way of living change rapidly, transformation of the educational system seems to be very slow. This is one of the main reasons why new technologies introduced

in education become obsolete and ineffective, often causing confusion among teachers and students, instead of offering better education.

Plato's Academia (in Ancient Greek called Ἀκαδημεια) was a place where only selected students could learn from special teachers in separated rooms (classrooms), using a chalk and a board. While the Academia existed for more than nine centuries, basic teaching methods and classrooms have barely changed (Petersen, 2004). The greatest confirmation for this fact is that blackboard and chalks are still the most important instructional tools in many schools, including Peter's small high-school.

On the other hand, as a computing competitor, Peter used several international online judges intended to automatically grade programming assignments and to prepare contestants for better results (Kurnia, Lim & Cheang, 2001). He discovered that any diligent student could learn from anyone and everywhere, and that recently, learning conditions and culture have dramatically changed.

This academic year, Peter enrolled at a faculty specialised in computer science (http://finki.ukim.mk/en/home), which will be addressed as FINKI throughout this paper. Peter understood that FINKI has already implemented several cloud solutions for his curricular and extracurricular activities. Therefore, Peter has recently gained knowledge about cloud computing and the opportunities it proffers in education and research. His findings are presented in the second section of the paper. The third section is dedicated to his particular experience with the different cloud services he went through. Following section presents the prospective systems integration in order to extend the cloud solutions to University and national level.

Although very impressed by everything he has gone through from the beginning of his study at FINKI, even Peter is aware that many changes have not been planned and studied in advance and that they were offered spontaneously and suddenly without a steady transition from one system into another. Therefore, he contrasts the benefits of the deployment of cloud services with the challenges they may bring.

The paper concludes that the crucial problem with the introduction of new technologies is the absence of a clear framework which will enable the standardisation of education in line with many everyday activities. Such standardisation is inevitable to enable a progress of education and its smooth transformation to new cloud computing era.

2 Academia in the 21st century

Peter's enrolment at FINKI coincided with one of his international competitions. His parents were ready to help him finish this traditionally very exhaustive administrative procedure. But, his experienced coach told him "While iKnow exists, you should not worry." Peter couldn't understand this sentence. The same day, he was first introduced to the eStudent Information System – iKnow, created and maintained by his prospective Faculty (Kirovski, Gusev, Kostoska & Ristov, 2012). Using this system, the whole enrolment process, including his early awareness of his good ranking was performed completely online.

For Peter, the first direct contact with the faculty was the inauguration lecture which was simultaneously presented on an interactive whiteboard like on international cable news channels. During brunch he went to the computer lab to write a small digest of previous classes. He easily logged in with his new Faculty account, but he was surprised that the computer's local storage was almost empty. He moved to another one. The situation remained unchanged. The desktop was empty. There were few, for him completely unknown programs, and almost no files. But, there were several Internet browsers. Peter was astonished. He twitted a short message with his first impressions: "The Faculty I chose must be in the clouds". He shared his doubt with his best friend who was already a sophomore there. His

more experienced colleague smiled and told him that his impression was true because the Faculty had moved to cloud computing for quite some time now. Curious as always, Peter decided to discover what cloud computing meant. The following text summarises what he learned after searching the Web.

2.1 Cloud computing in education and research

In the early 1960s, MIT launched the project named Compatible Time-Sharing System (CTSS), whose goal was to use "different parts of the hardware at the same time for different tasks" and to enable "several persons making use of the computer at the same time" (Corbató, Merwin-Daggett & Daley, 1992). This pioneering and visionary project lead to the development of two crucial concepts of contemporary computing: multitasking and time-sharing. The concept of time-sharing was not limited to making a computer "simultaneously available to many users in a manner somewhat similar to a telephone exchange", but also to facilitate sharing of computer resources.

In 2006, the same philosophy was modified and commercially implemented by Amazon Web Services (Cloud, 2011), when they first started offering their entire infrastructure as web services. Modern cloud computing was born. At that time, the initial aim was to create a balanced triangle between software, infrastructure and platform (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee et al., 2010), (Monaco, 2012).

Another surprise for Peter was his finding that the education of the 21st century had been significantly affected by new technologies which brought forth completely new teaching and learning tendencies. He realized that traditional blackboards were steadily being replaced with interactive whiteboards, textbooks with digital content, wired Internet connection with wireless Internet access, static E-learning 1.0 by dynamic E-learning 2.0. After acquiring his new smart phone, Peter suddenly had the opportunity to ubiquitously access his e-mails and Facebook profile. Interestingly, he discovered that new devices have affected learning as well, introducing the so called m-Learning where students and teachers could "assimilate learning anywhere and at any time" (Crescente & Lee, 2011). On top of the learning hierarchy, the promoter of E-learning, Cisco (Cisco, 2011) introduced the new concept of s-Learning, denoting social learning (Meyerson, 2012). Finally, Peter was aware that cloud computing was not only one of the most vibrant trends computing created so far, but that it has significantly affected the learning environment.

Once Peter learned what cloud computing meant, he decided to check which of his usual services belonged to the new paradigm. He realised that the key players in education clouds were technological giants like Amazon, Google, IBM, Intel, Microsoft and Oracle. He also learned that learning management environments used the knowledge of these "giants" and jointly incorporated various aspects of cloud computing in education. Eventually, he became conscious that the results of joint efforts in the development of technology and education were used by many universities worldwide. His new faculty was obviously not lonely in the cloud.

Then he asked himself what are the milestones of cloud education. He learned that since 2004, North Carolina State University had developed an open source Virtual Computing Lab (VCL) powered by Apache Software Foundation and supported by Intel and IBM. VCL nowadays provides numerous applications including Matlab, Maple, SAS, SPSS to more than 40000 students (Schaffer, Averitt, Hoit, Peeler, Siils & Vouk, 2009). Encouraged by the initial success, in 2009 VCL started pilot projects with students in the state, starting from middle school to higher education. At the same time, IBM created its Cloud Academy (ICA) together with countless educational institutions worldwide (ICA, 2010).

Peter was happy that as part of the initiative "Microsoft in Education" Microsoft Office 365 had been free for schools since June 2012 (Microsoft, 2013). Cloud solutions provided the infrastructure with on-demand computing and storage, while Windows Azure supplied the cloud platform and various online services. The great advantage of Microsoft's new services was the

freedom to adjust and modify the infrastructure to be adequately suited for university environments. Furthermore, Peter learned that after purchasing Sun Microsystems, Oracle retired Sun Cloud, one of the first cloud computing services intended to support innovations. Sun's motto at that time was "The Network Is the Computer" (Oracle, 2011). Although Oracle's cloud solutions Oracle Exalogic Elastic Cloud and Exadata Database Machine were primarily intended for enterprises, they were also adopted in learning environments to integrate their hardware with "virtualization, operating system and management software". In this way, they enabled education and research organizations to use cloud technologies like "virtualization-enabled self-provisioning of application environments".

In addition, Peter's favourite Google Apps had an extension for education which comprised several free applications: Google Docs/Drive, Google Talk, Google Video and Google Sites in two editions: for universities and for schools (Google, 2012). An interesting feature of these applications was the ability to customize all their products and services for the school domain. At the same time, costly server maintenance and complete back-end work were Google's obligation.

Peter's secondary school used Moodle as a Learning Management System (LMS). After discovering the power of cloud computing, he dug into Web sites and concluded that the cloud trends had tremendously affected learning environments as well. For example, LMS BlackBoard/WebCT have recently launched a learning object repository in the cloud named xpLor (xpLor, 2013). XpLor's basic goal was to move content to the cloud and to enable its global sharing from one LMS to another under Creative Commons in order to protect authorship and copyright. The repository supported multiple learning management systems and in November 2012 started beta testing in more than seventy educational institutions ranging from K-12 to universities (Nagel, 2012). Since 2008, Moodle has been hosted on Amazon Web Services (Moodle, 2012). Moodle was enhanced by BitNami Cloud Hosting enabling education institutions to move towards cloud hosting of their own websites and applications. BitNami Moodle 2.4 nowadays provides installation, virtual machines and cloud hosting on Amazon Cloud Formation (BitNami.com, 2013).

In 2012, Massive Open Online Courses (MOOCs) became an "educational buzzword" (Daniel, 2012). MOOCs are online courses that provide various online forums intended to build the community for students and teachers. They are usually based on open licensing and connectivism, where the role of social and cultural context is crucial. Their popularity is increasing, and many education providers offer MOOCs, such as Coursera, Udacity, edX, Erasmus and Academic Room (Smith, 2012). Similarly to new LMSs, MOOCs use cloud computing. Peter had already attended Univeristy of Helsinki's Java course (http://mooc.cs.helsinki.fi/programming-part1), which helped him become familiar with object-oriented programming.

In June 2012, Cisco Networking Academy had also moved into a cloud - based on the learning management system named Canvas, which is now accessible through Apple devices. Their new platform Cisco NetSpace (Cisco, 2011) is intended to be used in their academy which is a partner of more than 10000 institutions, including FINKI. Peter will undoubtedly have the opportunity to attend their courses very soon.

In the end, Peter was convinced that his decision to study computer science at FINKI was correct. His enthusiasm for science motivated him to search a little bit further and check whether he could use this new trend for research as well. He found out that the fascinating expansion of cloud computing and successful integration of cloud solutions into various learning environments has affected universities to intensively employ "massively scaled computing infrastructures" for research purposes. IBM and Google Cloud Computing University Initiative launched the Cluster Exploratory (CluE) program (IBM, 2009). The program was supported by the US National Science Foundation, which awarded the most prominent US universities with grants to pick up cloud computing projects. Within three years, the massive cloud cluster Hadoop performed more than 120 million computing tasks. Google withdrew from the program in December 2011 after realizing that from "state-of-the-art", their support became "worldwide phenomena", because of "many

low-cost cloud computing options that provide viable alternatives to the Academic Cloud Computing Initiative" (GigaOm, 2011). Apparently, CluE mission was accomplished, while research and education of outstanding universities had enormously benefited from this program.

Where is Peter's faculty in this story? The following part of the paper presents modest, but valuable steps towards the adoption of available cloud solutions in education at FINKI and the experience of integrating these solutions with the existing high-performance infrastructure.

3 FINKI and the clouds

Peter enrolled at the greatest technical faculty in the country, which is a long-time leader in computer education. Peter became a part of the FINKI student society consisting of more than 3000 students. Immediately after enrolling at FINKI, he got access to office services offered by Office 365, together with the cloud-based email service Outlook.com (Microsoft, 2013), as a result of the partnership of his faculty with Microsoft, initiated in the 2012/13 academic year. As part of the Office 365 experience, FINKI's staff and students have access to private e-mail addresses, as well as other services provided by Microsoft. Every student and teacher has access to Microsoft Live accounts that can be used for instant messaging communication, using the MSN protocol. Teachers and students use other types of communication for private use, but they use their FINKI Live accounts for communication. Peter has already communicated with the staff, despite not being able to be physically present during office hours. Furthermore, he has smoothly and easily accessed Microsoft software for educational purposes.

As part of the same initiative, file-sharing of official documents is currently moved from Microsoft SkyDrive (www.skydrive.live.com, Fig. 1 left), to newer version Microsoft OneDrive (https://onedrive.live.com), but Dropbox (www.dropbox.com) has been intensively used by teaching staff to enable exchange of prepared lectures, support of study resources, and course maintenance (Fig. 1 right).

For several years, Peter has been excited by blockbuster movies, so he decided to learn how they were created. Therefore, he joined the Computer Animation Club. Each year, students from

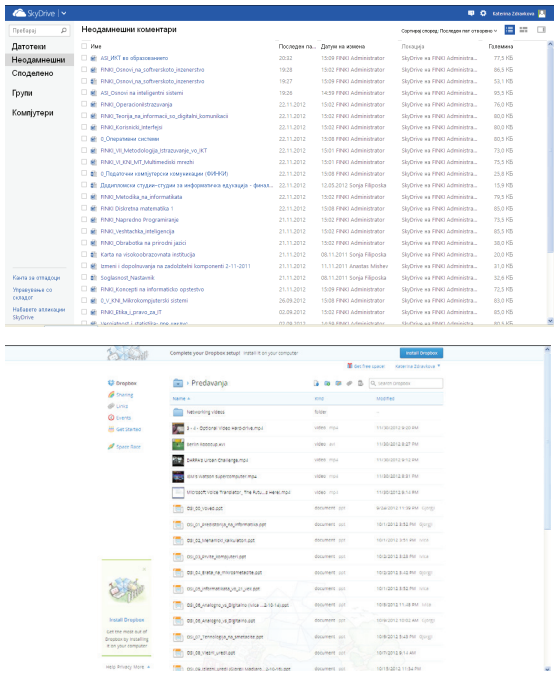

FIGURE 1. Microsoft and Dropbox file-sharing systems at FINKI

this group collaboratively create small 3D animations. This group meets once per week in order to discuss the assignment, all the ideas how to accomplish it, in addition to the current status of the whole project. For file sharing, Adrive (http://www.adrive.com/), FilesFINKI (http://bgp.he.net/dns/files.finki.ukim.mk) and Dropbox are used. Apart from FilesFINKI, as a support for the creation of animated video FINKI uses its infrastructure to create a new open-source cloud production asset management system Tactic (Tactic, 2013). Since the

Computer Animation Club consists of less than 50 members, Tactic (Fig. 2.) is very useful to create large scale content. It provides better control, easier communication and complete access to all the elements necessary to manage one digital project.

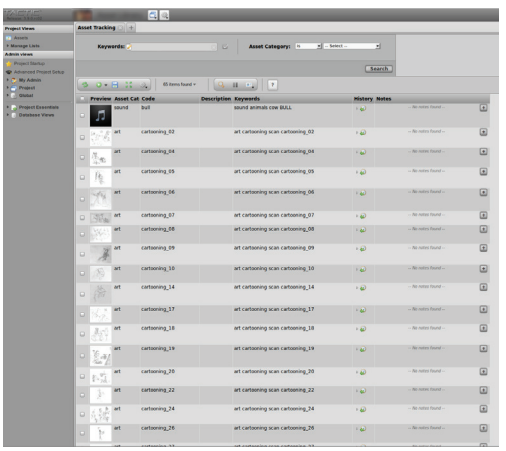

FIGURE 2. Tactic is preferred asset management system in the Computer Animation Club

During the first club meeting, Peter experienced his first privacy anxiety. Namely, the mentor asked him about his Facebook profile. Peter knew that Facebook was very popular in his country where about 80% of all Internet users had Facebook profiles (EIUS, 2012), however for him, this social network was a place for private communication. It was true that during the first weeks of his student career he had already joined several Facebook groups created by his colleagues. They were intended for mutual communication, exchange of curricular material and experiences about ongoing exercises, tasks and assignments among students on particular courses. But, activities within these groups were hidden and could be accessed upon invitation only and teachers were not invited. Therefore Facebook provided a safe environment or a "safe harbour" for him and his new friends.

Peter knew that his faculty liked new media very much. He learned the enrolment procedure from YouTube, his future teachers and assistants from LinkedIn, and even saw his future diploma on Flickr. Like more than 9300 people, he liked FINKI on Facebook (https://www.facebook.com/FINKI.ukim.mk), and he followed its tweets on Twitter (https://twitter.com/FINKIedu). But his own profile was his private matter. Therefore, he ignored the teacher's invitation to become a group member.

During the next meeting, Peter found out that he missed initial suggestions about his first assignment. All other colleagues had already studied ways to create an animated logo, and they discussed a lot on the Facebook group, sharing ideas and free on-line tutorials on services like Vimeo (https://vimeo.com/) and YouTube (www.youtube.com/). It appeared that all of them accepted the invitation and downloaded the Blender tutorial (www.blender.org/education-help/tutorials/), which was recommended by the teacher (Fig 3. left). He contacted his sophomore friend again and found

FIGURE 3. Two typical Facebook groups used for collaborative content creation

out that FINKI's students participated in two types of Facebook groups, private for student communication and sharing only, and another private, but for students and teachers. He even sent him a figure of his team project assignment where the teacher was also present (Fig. 3. right.). Peter eventually got over his privacy anxiety, and accepted the invitation to join the group via his private profile.

It appeared that the Facebook Computer Animation Group was actually initiated by students. They used it intensively to coordinate and manage their project, to post their outcomes, to communicate or to ask for advice about certain problems during project creation, to share tutorials and interesting animations about video services, and finally, to initiate additional meetings out of the regular schedule. Teachers were invited to resolve occasional dilemmas, and to suggest solutions whenever it was required.

As part of his curricular activities, Peter soon started gaining his first experience with professional clouds. In his basic programming courses, he was introduced to cloud based repositories for version control management like GitHub (https://github.com/), BitBucket (https://bitbucket.org/), Google Project Hosting (https://code.google.com/hosting/) and SVN (http://subversion.apache.org/). His view of Bitbucket/Github used in the Web Design course is presented in Fig. 4.

Peter discovered an additional benefit of cloud

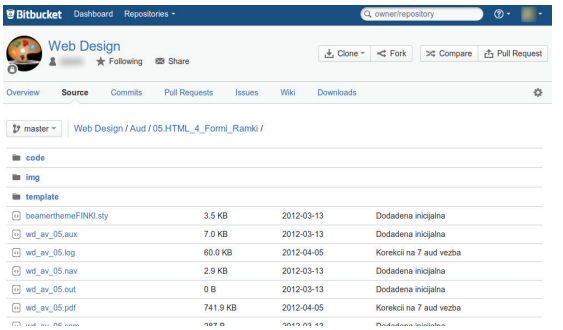

FIGURE 4. Bitbucket/Github is used in Web Design course

solutions. When his USB started behaving strangely, he suspected that it was infected with some viruses. However, his home anti-virus program didn't detect anything. Therefore, he remembered to check it using Panda Cloud Antivirus (http://www.pandasecurity.com/homeusers/downloads/), another cloud solution he learned about in one of his courses. He was surprised that this solution was more sensitive and effectively found the threat.

Peter's first impression that his faculty is in the cloud was still present, but he learned that education in the cloud could be a nice and successful solution for many everyday activities, particularly those involving communication, access to various learning resources, file sharing, and collaboration.

4 Systems integration

Since his first days at FINKI, Peter has used several E-learning systems working in cooperation. He knew that they required broad and complex logistic operations to function properly. The two major prerequisites to access these systems were: authentication to the systems and enrolment of students as well as assignment of Faculty staff to courses. FINKI tackled both issues with solutions that provided ease of use for students and required minimum effort from the staff. Peter was aware that whenever multiple systems were employed, a major milestone was their integration.

Peter discovered that the authentication issue was solved by integrating the Central Authentication System (CAS) currently in use at the faculty (Fig. 5.). He already knew that the iKnow system he used to enrol the Faculty was also used by the entire University (Kirovski, 2012; iKnow, 2011). The e-Student Information System iKnow is designed to store and administer students' records and personal files, as well as related university data. It was developed using an innovative approach and knowledge management techniques. The system provides exchange of electronic information among the entire university society: administration, teachers, students and university management. Currently, the system is ending its testing phase and it is entering full use.

The data in the system is kept up to date and is constantly administered by students, teachers

and student services personnel. Therefore, updated information for the enrolment of students in courses is always available from the system through web services or graphical web user interface. At the same time, CAS functionalities are currently provided only to FINKI students. The idea in CAS is the single sign-on concept where students log on only once, and can be considered as signed in to all the services provided by the faculty, including but not limited to: e-Learning systems (Moodle, LE), Student management system iKnow (Kiroski, 2012), e-Assessment cloud system (Ristov, Gusev, Armenski, Bozinoski & Velkoski, 2013), and online testing and laboratory exercises system eLab, which is still under development. After typing the username and password in the standard form, Peter, his colleagues and staff are issued a ticket and redirected to the service they initially browsed. As long as the ticket is kept alive (saved in the browser), the user can access all of the services provided by the faculty. The advantages of using the single sign in service are multiple. The ease of use and time saving is significant since the user / pass combination is entered only once and the users need to remember only one pair of username and password on the predetermined HTTPS web form (Fig. 5.). Also, security is increased and the danger of phishing is reduced.

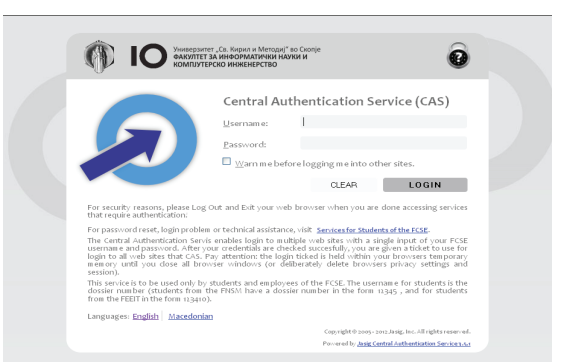

FIGURE 5. Integrated central authentication system

While iKnow is a university information system, student information systems presented in this paper are faculty related. The architecture of the system and the idea behind it is to migrate the system to the cloud and transform it into a service that can be used simultaneously by several universities. Preparations are underway for the migration of the system, along with its integrations and connected systems. Recently, FINKI has established a High Performance Computing - Supercomputer infrastructure for deploying various cloud solutions. The supercomputer consists of 84 servers, each server using 2 microprocessors (168 in total) and each processor having 6 cores (1008 cores in total). Therefore the total number of logical processors is 2016. The blade servers are interconnected through InfiniBand (InfiniBand, 2013), using 84 separate links in order to provide reliability and robustness.

The established infrastructure is awaiting the expansion of the e-Learning services, currently provided only by FINKI, towards the entire university and even beyond, to other universities. The pre-tested integrated systems: Central Authentication System, Moodle learning system, e-Assessment system as well as the core iKnow system along with various additional services have proven their capability to efficiently manage services. A step further is the connection of various Moodle courses and sharing of information among them. Furthermore, a new version of the e-Assessment system, which has already been tested in secondary schools, intends to enable sharing of questions among different related courses.

The inclusion of additional informative systems, like scheduling, video sharing, and blogging, is easy and straightforward and is based on experiences from previous integrations. Simultaneous implementation of all the services by thousands of FINKI users proved their scalability, promising successful extension from faculty to university and in perspective from university to national level.

Many researchers and students from FINKI have already used the private OpenNebula cloud services offered by the faculty called Nebula (nebula.finki.ukim.mk). They are integrated with FINKI single sign on supporting .NET, PHP, MS-SQL and MySQL (Jakimovski, 2013). Another great advantage of FINKI's private cloud services is their integration with the massive cloud cluster Hadoop, which enabled the execution of various memory and process demanding projects

mainly performed by FINKI staff and senior students. Nebula private cloud services are offered to the university as well. Since OpenNebula is a part of EGI Federated Cloud (http://www.egi.eu/infrastructure/cloud/), the further extension of private cloud is to integrate it inside European Grid Infrastructure (https://www.egi.eu/).

Few years ago, cloud computing in education was "ante portas". Meanwhile, at many universities worldwide cloud services have already become ordinary solutions. As presented in this paper, FINKI uses many software solutions and various platforms as a service. A high performing computing infrastructure is offered as a service in parallel with an infrastructure provided by Microsoft, FilesFINKI and many others.

5 Contrasting benefits and challenges of cloud solutions

Peter's initial impression that his faculty was in the clouds was actually true. He experienced many cloud computing services his faculty offered and managed to cope with them flawlessly. His colleagues became familiar with technological novelties too. He noticed that at the same time as his younger teachers felt very comfortable "in the clouds" more experienced teachers avoided them whenever possible, the latter not surprising for him. His parents were exactly the same. Their excuse was their rejection of organisational change is usually highly influenced by the habits and resistance to change (Graetz, Rimmer, Lawrence & Smith, 2012). Considering the refusal of more mature to accept the change, Peter realised that there was a dichotomy between those who use cloud solutions on a daily basis, and those who have never experienced any cloud service. It convinced him to contrast the benefits to potential challenges. His conclusions are elaborated in the next paragraphs and briefly presented in Table 1.

The best of all was that Peter was not supposed to install anything on his computer already crowded with software and games, while these services were always available online; even by his mobile phone. Cloud solutions were ready to use, offering him immense pools of various resources. Person-to-person and group communication and communication, as well as the exchange of curricular and extracurricular materials fascinated him, too.

Teachers' opinion was that these solutions could be very useful as a support to the educational process. Many of them were convinced that cloud education was actually more exciting and more effective than traditional education. More conservative teachers were rather doubtful, particularly those who were familiar with the Policy Brief by UNESCO IITE (Sclater, 2010). Peter read this report and noticed that some of the new unsolicited advertisements, together with signs and banners popping on his screen appeared after he started using some cloud solutions which he discovered himself. Another interesting conclusion was that only few of his favourite solutions, mainly Github, BitBucket, Google Project Hosting had clear privacy and cookie collection policy, while Adrive, Tactic, Blender and SVN were a potential risk.

Another obvious problem was data security, although the most popular cloud solutions had strict security protections. However, no site is completely safe from different security threats. Peter has already experienced unusual malwares, and received strange phishing messages after he started using cloud software, platforms and infrastructure. He still believes that this was a pure coincidence, but - once bitten, twice shy.

On one occasion, Peter was very upset when his cloud service was not available. And, the worse was that his backup copy was in the same cloud. The problem persisted almost one week. He wanted to believe that the reason were potential failures of cloud infrastructure, or his temporary inability to access it. But, there were rumours that the service will no longer be free. After that single incident, he started making local backups for himself although without the cloud platform his projects would not be useful any more, calling in question the sustainability of cloud services he used, as well as the possibility to migrate them to new service environments.

Concerning his own projects, Peter was not worried about outside hackers and crackers. He was more scared that the administrators of his tools might access them easily and use them without his permission. He was also not sure under which

licence he developed his projects, particularly because he was using several applications to create them. When he and his colleagues wanted to somehow protect their ideas, they were told that it was not possible, because similarly to laws of nature, and natural phenomena, abstract ideas are not patentable (WIPO, 2013). These property matters worried him a lot.

Peter was sure that the number of open questions was much bigger. They will become visible after more intensive use of cloud solutions, particularly if cloud services start replacing conventional services.

Table 1. Benefits and challenges of implementation of cloud solutions

Benefits	**Open questions**
Infrastructural: • No need to install new software. • Online availability of immense pools of resources. • Online availability of various services. • Reduced demand for self storage. • Ready to use solutions. • Ease of use and time saving. • High scalability of offered services due to distributed primary data centres. • Distributed virtual data centres and high-availability clusters. Educational: • Cheap or completely free academic solutions. • Smooth and easy access to different software solutions for educational purposes. • User friendly and easy to learn applications. • Exchange of prepared lectures and supporting study resources, • Enabled course maintenance. • Enabled gradual transformation of conventional learning environments. • Enabled smooth upgrading of learning solutions. Collaborative: • Enabled person-to-person and group collaboration.	Security threats: • Are cloud solutions protected against malicious software? • Does danger of phishing exist? • Can collected cookies be misused? Reliability problems: • Is cloud infrastructure protected from failures? • Is the functionality of data storages guaranteed and how? Terms of use and licensing: • Can imprecise or ambiguous terms of use be resolved? • Are terms of use too demanding? • Are licensing policies conflicting? Privacy threats: • How to protect against spam and unsolicited advertisements? • Can cloud solutions cause potential privacy anxiety? Availability problems: • Is there a risk of temporary or permanent breakdown of cloud services? • How to ensure permanent access to cloud solutions? • What is the reason of unavailability of remote data and how to avoid it? • Can constant access to services and data be assured?

- Enabled exchange of curricular materials and experiences among teachers.
- Enabled exchange of experiences about ongoing exercises, tasks and assignments among students.

Managerial:

- Enabled integration of various cloud solutions.
- User-directed solutions.
- Better control, easier communication and complete access to all the elements necessary to manage digital projects

Sustainability:

- How long will free cloud services and solutions be available?
- How long will free cloud solution remain free?
- Will the price of commercial cloud services be affordable?

Property dilemmas:

- Who can access the source code and projects developed in the cloud environment?
- Who possesses the source code?
- Can software projects be protected?

Access:

- How does offline - online dichotomy affect implementation of cloud solutions in education?
- Can the resistance to change be avoided?

6 Conclusion and further work

Education is one of the most important human processes. It is unavoidable to learn day after day to stay engaged in the modern world. Therefore, education is more important far more than ever. To speed up important activities and functions, human beings standardise them. For example, we live in standard rooms, houses and cities; we transport ourselves using standard vehicles: cars, trains, boats or planes. Equally, but less and less frequently we learn in traditional classrooms with chalks and blackboards.

Emerging technologies and plentiful opportunities that they trigger don't let us standardize learning and education. Moreover, possibility to learn always, everywhere and from everyone makes standardization of the learning process easier said than done. However, it doesn't imply that we should a priori give up from any activity in the direction of regulating the process. On the contrary, we should try to make it possible. Exactly the intention to improve the learning process in line with new trends was the inspiration to write this paper. It is not exactly Peter's experience, but rather the teachers' challenge to prove that education can enormously benefit from new technologies.

With this paper we simply tried to convince readers and ourselves that the examples of recent modifications done at our faculty are a significant contribution to education reconstruction and innovation. They support and stimulate research as well, enabling a successful completion of many exhaustive projects smoothly and efficiently. Moreover, we emphasise that modern academia attempts to regulate chaotic and vivid situation by attentively studying all the elements of the educational process, and implementing the most challenging technologies. Students see the usage of all cloud services as their normal activity. Teachers should learn that too.

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