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Developing a Course for Learning Mathematics through Programming

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The aim of this Master thesis was to develop a course for learning mathematics through programming and propose how such a course could be run in a University of applied sciences.

To develop such a course, this study includes research on compatible online learning systems and platforms applicable for Metropolia; selecting the best online learning systems and platforms which met the needs of Metropolia; developing and finally testing a pilot hybrid course for the Bachelor's students. The aim for this online-course was to boost their interests in mathematics though programming as a means of getting this knowledge, as well as to utilize this option for reducing operational costs.

The study begins with introducing e-learning and various systems of massive open online courses, comparing them to find the best for the needs of Metropolia, selecting an EdX system and platform as the open online system and platform, and then designing, implementing and testing a new ICT Mathematical Applications course. This study continues with analyzing feedback gathered from the students and the instructor of this ICT Mathematical Applications course about using the EdX system and the new course.

The study could be continued by developing and deploying an EdX online environment and making other hybrid course and collecting more feedback in order to create a better environment for the students and reducing the operational costs of running a University of Applied Sciences mathematics courses.

Keywords	CMS, Coursera, EdX, EdX functionalities, EdX modules, EdX platform, EdX technology, e-learning, LMS, MOOC, Udacity

Contents

1 Introduction

The purpose of this Master thesis was to develop a course for learning mathematics through programming and propose how such a course could be run in a University of applied sciences. To develop such a course, this study includes research on compatible online learning systems and platforms for Metropolia University of Applied Sciences, select the best online learning systems and platforms which met the needs of Metropolia, and develop a pilot hybrid course for the students regardless of the level study of these students. There are two reasons for the urge for online learning systems and platforms for Metropolia. The first reason is that the students of ICT at Metropolia are more interested in programming but less in mathematics. Therefore, it was decided to combine these topics and start such a course. It is planned that such a course will boost their interests in mathematics though programming as a means of getting this knowledge. The goals are to offer a wider selection of courses, which can suit a variety of needs of its students, without compromising on the quality. The second reason is the financial pressures for cost reductions in the public sector to educate the students who are studying in Finnish University of Applied Sciences, including Metropolia University of Applied Sciences. It is a challenge when the funds are reducing. Therefore, the goal of this project is to develop a new ICT Mathematical Applications course for the Information Technology Program to address these needs.

The new ICT Mathematical Applications course suggests learning mathematical statistics through Python programming. The team members of this project are Sakari Lukkarinen as a project leader and instructor of the course, Umesh Satyal as innovation project worker and Ali Ramz as a Master's Degree student. Sakari Lukkarinen developed the content of the course. Umesh Satyal and Ali Ramz researched and analysed the EdX system and platform and selected the online system and platform, designed, developed, implemented and tested the new ICT Mathematical Applications course. In the end of the course Ali Ramz collected feedback from the students and the instructors about using the EdX system and ICT Mathematical Applications course in the end of the course. Ali Ramz also collected feedback from the other instructors familiar with the EdX system about the EdX system.

The EdX system is an open source platform. It was launched in year 2013 and any individual, group or community can use it for their own purpose. In year 2013, the students of Media engineering of Metropolia installed the EdX system as testing environ-

ment in the servers of Metropolia. The EdX project was led by Hannu Markkunen, and the administrator of the EdX environment for Metropolia was Matti Peltoniemi. The aim of this group was to develop and add new features and various courses which met the urge of Universities of Applied Sciences for more online courses. At this moment, human resources for this project are voluntary contributions of different lecturers and students of Metropolia University of Applied Sciences.

2 E-learning

E-learning applies to the exploit of different sort of electronic, information and communication technologies (ICT) and media in education. It is a large term for educational technologies, which support learning and teaching electronically or technologically. It can be referred as computer-based training (CBT), web-based training (WBT), Internet-based training (IBT), and technology-enhanced learning (TEL), digital educational or virtual education collaboration depending on the emphasis on a delivery method, specific aspect or component. It includes different types of media that deliver audio, images, text, animation and streaming video and includes processes and technology applications. It is communication and information distribution which is created by using existing Internet technology. In fact e-learning is the use of the Internet technologies to bring solutions that amplify knowledge and performance. It is an approach to learning and development. E-learning can be blended learning (distance learning or in conjunction with face-to-face teaching), synchronous learning (instructor-led) or asynchronous learning (self-paced). [1, 28-29].

2.1 History of E-learning

The term "e-learning" was first utilized at a CBT systems seminar since year 1999. At the same time other words such as appeared “virtual learning” and “online learning”. According to history, early forms of e-learning existed as far back as the 19th century and the principles behind e-learning have been well documented throughout history. Long time ago before the Internet was brought to the market, distance courses were being offered to provide the students with education on special skills or subjects. In year 1840 Isaac Pitman started to teach his students through exchange of letters. [2]

This form of symbolic writing was designed to improve writing speed and was popular among journalists, secretaries, and many other individuals who did a great note taking or writing. For the first time a teacher called Isaac Pitman sent completed assignments by mail to his students and asked them to do them and send them back by mail to him. In year 1924, the first simple testing machine was invented. This device permitted students to test themselves. [2]

In year 1954 Harvard University Professor, BF Skinner invented the “teaching machine”. Teaching machine was a device which provided for schools to administer pro-

grammed instruction to their students. In year 1960 the first computer based training program was built. It was known as PLATO-Programmed Logic for Automated Teaching Operations as well. Originally it was designed for students who attend in the University of Illinois. It was being used in schools throughout the area of the University. The first systems of e-learning were only set up to provide information to the students but during 1970-1980 e-learning started to become more interactive. When World Wide Web came to the world, the Open Universities started to offer a more extensive range of interactive educational experiences to their students via email which was faster method than normal mail. By the introduction of the Internet and computer in the 20th century, e-learning tools and delivery methods got more expanded. [2]

In the1980, the first MAC machine (personal computer, made by Apple Inc) provided for the individuals to have computers in their homes. This opportunity allowed them to learn about particular subjects and develop certain skill sets. In the following decade, virtual learning environments began to succeed and people gained access to a wealth of online information and e-learning opportunities. In the early 90s a small group of schools started to deliver courses in online form and bring education to people who wouldn't previously have been able to attend in a college due to geographical or time constraints. The advance of technology helped educational establishments by reducing of the costs of distance learning and bringing education to a wider audience. In the 2000′s, businesses began to educate their employees by using e-learning. Now experienced and new workers have possibility to develop their industry knowledge base and expand their skill sets. At home, the individuals are granted access to programs which offer them the ability to gain online degrees and improve their lives through expanded knowledge. [2]

E-learning has three significant criteria. E-learning focuses on the most comprehensive prospect of learning-learning resolutions. E-learning is delivered to the end-user via an information and communication technology. [1, 28-29]

2.2 Benefits and Drawbacks of E-learning

E-learning has many benefits. These benefits refer to the wealth of e-learning which can carry brand new futures to the educational system in order to teach and study. Here are the most important benefits of e-learning.

The study program can be customized for different learning demands or different types/groups of people. The Internet enables the learners to build up an enduring society of practice where they share knowledge after a training program finishes. E-learning is often the most cost-effective way to deliver instruction (training) or information. No cost for trips and it does not require for instructor/classroom infrastructure. The content of e-Learning can be directly updated or upgraded and distributed to the learners through the Internet. Learners can retrieve e-learning anywhere at any time. The solutions of e-learning are extremely scalable. [1, 30-31]

Not only a few participants but also an inexhaustible number of participants can be involved in training programs. The Internet technology is getting more familiar for people every day, so access to e-learning through the Internet technology is not issue anymore. Larger number of people can be reached virtually and contemporarily. Effective and engaging use of e-learning helps customers lead increased benefit from the site. Executives are increasingly searching ways to exploit their investment in Internet companies. E-learning emerging is one of those applications. E-learning is web-enabled and it has advantage to use the worldwide Internet protocols and browsers. Everyone can receive virtually the identical material on the web. [1, 30-31]

E-learning also has several drawbacks. These drawbacks refer to the ineligible futures of e-learning which can be threads to the educational system in order to teach and study. Here are the most important drawbacks of e-learning.

It is possible that without the structures as in a normal class, some students may get confused in e-learning courses. Students with beginner-level of ICT skills may not manage with an e-learning platform. Accessing course materials may be frustrating with old computers or poor Internet connection. It is possible that the instructor may not be available at the same time when the students need guidance. It is not easy to simulate lab courses in e-learning courses [3]

2.3 E-learning Infrastructure and Tools

There are seven various key factors about an e-learning infrastructure and tools presented below.

The learners should have access to the Web by at least medium-speed connections inside or outside the campus or offices. A good and mutually beneficial relationship between the training and IT community is essential. The e-learning portals should be well designed and it should be easy for people to find and use them. Having a substantial e-learning strategy is extremely important for interest of the companies or the universities. A good learning management system is very important to systematic management of e-learning; multiple learning management systems can easily induce confusion across all the e-learning efforts. The organization of e-learning in the companies or the universities should have interoperability with its company or University. The organization of e-learning should have the right talent and positioned in the right roles in order to make the best use of its learning infrastructure and tools. [1; 176, 177]

These factors make the value of e-learning. The value of e-learning is the sum of its ability to generate benefit to the skill and the knowledge of the learners. E-learning improves the job performance of the employees. E-learning impacts the results. E-learning saves the money of the University or the company. E-learning is available to anyone at any place at any time.

In other words, the value of e-learning is the sum of the elements such as the Cost Efficiency of e-learning, the Quality of e-learning, the Service of e-learning and the Speed of e-learning. [1; 227]

2.4 State of E-learning in Higher Education

At the present time the students have demand for more technology. The technology has accelerated the drive for e-learning initiatives in higher education. Generally institutions want to improve in the areas of policies, governance and outcomes assessment around e-learning plus investment in faculty and staff. Especially the smaller institutions are behind in their e-learning initiatives. The reason behind it is that, they concentrate on the cost and popular technologies and services rather than on what will be the most effective solution for their institution. It is possible that smaller institutions get benefit from partnering or outsourcing with vendors, companies or other institutions for e-learning provisioning. [4]

The IT leaders are most perturbed about the technological know-how of the faculty and the sufficiency of e-learning staff. In selecting e-learning the technologies and the solutions, the institutions emphasize in reliability, security of student data and ease of use for both students and faculties and effectiveness. The IT leaders are sure that, their institutions are ready to increase using of e-learning technologies and services. [4]

The best guidelines in e-learning in higher education are such as making e-learning initiatives part of the institution's tactic and financial plans and set particular target for e-learning initiatives, faculty development programs should be deployed e-learning technology, establish the clear incentives for e-learning, assign a center or office for e-learning management, institutions which are behind on e-learning initiatives should consider partnering or outsourcing with others for online content, student support, services and infrastructure resources, evolve a strategy for recognizing the students who need technology tutoring, estimate and consider increasing the number of staff to support e-learning initiatives, make sure that designing of the course is as flexible as possible, and in selecting e-learning technologies and services, concentrate on ease-of-use, criteria, contribution to learning objectives, ease of integration, specific features, reliability, effectiveness and security. [4]

2.5 Responsibility and Role of Members of E-Learning Team

The construction of an e-Learning team varies depending on the number of the employees of the e-Learning organization. The significant roles for building an e-Learning team followed by the liabilities of each role in an e-Learning team are the project manager, the instructional designer or writer, the editor, the graphical designer, the media specialist, the authoring tools specialist and the tester.

The task of the project manager is to supervise the life cycle of the project and the schedules of the delivery, connect e-Learning team and internal client, provide all the resources and the information that e-learning team needs and provide the business analysis to verify that all solutions are reached out with the organizational and the business goals.

The task of the instructional designer or writer is to know how use collaborative tools and social media, analyses content, organizes content, use instructional design, know

about theory of the adult learning and the cognitive psychology, design solutions, write the scripts and the storyboards, performance the support and know about the manuals and the mobile learning.

The task of the editor is to enhance common writing and proofread all the writings. The task of the media specialist is to produces and edits video and audio. The task of the tester is to test the course from the technical point of view and ensure that the course accommodates the storyboard.

The task of the authoring tools specialist is to compile all the components into the running e-learning course, raise interactivity and make sure that the e-learning course can match with the related Learning Management System. The task of the graphic designer is to build up the user interface, create the graphics and the animations, design the look of the e-learning course, design learning portals of the e-learning course and design of the mobile learning of the e-learning course.

An overall misapprehension is that the e-Learning team must have experience or expertise in all the subjects they teach. In practice, the educational designer operates with the experts of the subject matter to evolve the content of the e-learning course. When the teaching subject of the e-learning course is new within the organization, the educational designer should research the subject of this e-learning course using journals and books or interview the experts who are in the field. [5]

2.6 Process of E-learning Project

The process of an e-learning project is divided to the seven stages. These seven stages in order are analyzing, designing, developing, implementing, evaluating, maintaining, training and support. [6] Figure 1 below illustrates the seven stages of an e-learning project.

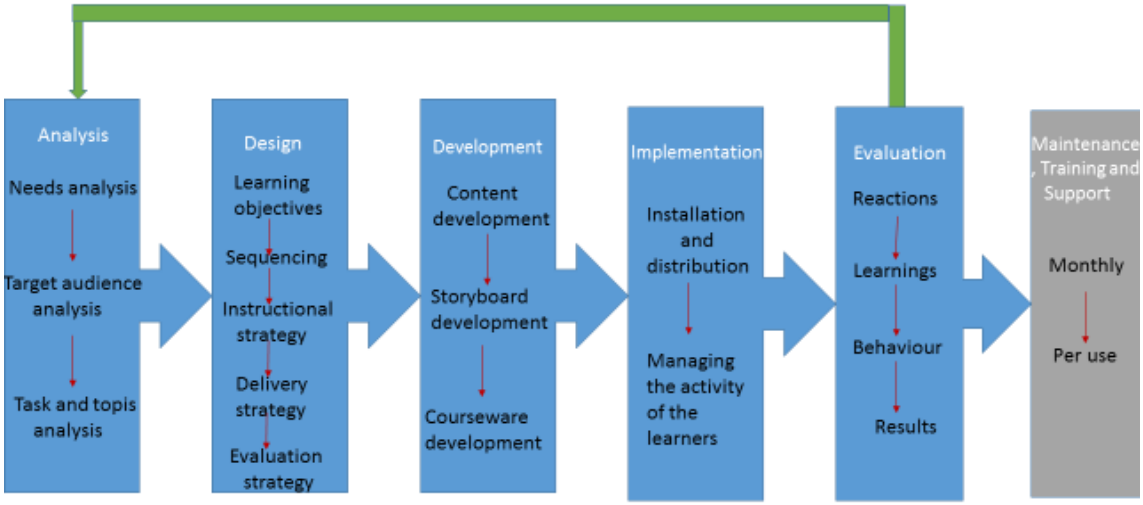

Figure 1. The stages of an e-learning project

The first stage to build an e-learning project is analyzing the needs for an e-learning course. The analyzing the needs for an e-learning course causes gathering information to realize how to service the objectives and the high level course goals of an e-learning course. This analysis should identify the skills and the knowledge of the learners of that e-learning course which need to be developed as well. Finally, the analysis of the topic is conducted to classify and identify the content of the e-learning course. [6]

The design stage of an e-learning project consists of the next steps such as developing a collection of the learning objectives required to achieve the high level course objective, specifying the sequencing the objectives which should be achieved selecting the instructional strategy, selecting the strategy of the media, selecting the strategy of the evaluation and selecting the strategy of the delivery. The conclusion of the design stage are such as the structure of the e-learning course, the structure of the lessons and units of the e-learning course, learning objectives which are linked with each unit of the e-learning course and delivery of the formats and the methods of the e-learning course. [6]

In the developing stage, the content of the e-learning course is produced. Depending on the available resources the content of the e-learning course can vary. For the developing of the learning materials of the e-learning course that include multimedia interactive content the process consists of three main steps such as content development, storyboard development and courseware development. Content development is

the collecting or the writing of the required information and knowledge. Storyboard development is the integrating media elements and instructional methods. Courseware development is the developing media and interactive components of the e-learning course, generating the e-learning course in various formats and web delivery and integrating the elements of the e-learning course into a learning platform. [6]

In the implementation stage, the e-learning course is delivered to the learners. The courseware of the e-learning course is installed on a server and the learners of the e-learning course have access to the e-learning course. The implementation stage contains the managing of the activities of the learners. In the evaluating stage, the reactions of the learners of the e-learning course will be evaluated. The achievement of learning objectives of the e-learning course will be evaluated. The skills and the knowledge of the learners and the impact of the e-learning course will be evaluated. In maintenance, training and support content management system of the e-learning course will have security updates, system upgrades, version upgrades and general website of the e-learning course will be maintained. [6]

2.7 Fundamental Components and Tendency for E-learning

In my opinion, the three fundamental components of e-learning are content, technology and learning design. These three components complete each other. The content should be powerful and succinct. The learning design should raise the content. The technology should be able to enable both the content and the learning design. [7]

According to the e-learning industry the tendency for e-learning in year 2015 are such as "how big data analysis can improve e-learning", "why gamification is important", "accepting of personalized learning", "benefits of mobile learning", "what to consider when costs of e-learning should be considered", "possible using of various applications in an e-learning context", "possible uses of augmented learning", "possible corporate use of MOOCs" and "rise of cloud of learning management system". [7]

2.8 Learning Management System and Content Management System

A learning management system (LMS), such as Moodle, sakai, paradiso, emodo and eCollege, is a software application for the documentation, reporting, administration, tracking and delivery of e-learning courses or training programs. The LMSs vary from

systems for managing training and educational records to software for distributing online courses over the Internet. The universities and the colleges use the LMSs to deliver online courses and increase campus courses. The corporate training departments not only use the LMSs to deliver online training but also to automate the employee registration and record-keeping. A robust LMS should be able to assemble and deliver learning content rapidly, centralize and automate administration, consolidate training initiatives on a scalable web-based platform, personalize content and enable knowledge reuse, support standards and portability and use self-service and self-guided services. [8]

The LMS functionalities are such as certification and curriculum management, courseware authoring, course content delivery, individual development plan, reporting, resource management, skills and competencies management, skill gap analysis, student administration and registration, training event management, training record management, skills and competencies management, skill gap analysis, student administration and registration and virtual organizations. [8]

A content management system (CMS) is a computer application which permits editing, modifying, deleting, organizing, publishing and maintaining the content of e-learning. CMSs are often used to run websites which contain news, blogs and shopping. Many marketing websites and corporate use CMSs. Typically CMSs goal is avoid the need for hand coding. But it may support it for specific elements or entire pages. Content management systems stores, organizes files and provide version-controlled access to their data. The features of content management systems range widely. [9]

Most CMSs format management, indexing, search, revision control, Web-based publishing and retrieval. The version numbers of CMS increment when new updates are added to an already-existing file. Some content management systems may support the separation of the presentation and the content presentation. A CMS may serve as a central repository containing scientific data, documents, pictures, movies and phone numbers. CMSs can also be used for controlling, revising, storing and semantically enriching and publishing documentation. [9]

The content management system consists of two components such as content management application (CMA) and content delivery application (CDA). Content management application is the front-end user interface that permits a user even with limited

expertise, to add, modify and remove content from a Web site without the intervention of a Webmaster. Content delivery application compiles this information and updates the Web site. Some content management systems are such as WordPress, drupal, joomla, exprssionEngine and radiant CMS. [9]

3 Massive Open Online Course (MOOC)

A massive open online course (MOOC) is a delivering model of online learning content to the massive participation through World Wide Web. They can include video lectures, learning material, assessments, tests, new evaluation systems (automatic examination of closed questions, peer evaluation examination through artificial intelligence), blogs, discussion boards and commenting via social media platforms. The open learners, who do not pay anything for course entrance, can participate in all or some of the course activities. It is possible that open learners do not receive credit for the course or get little or no direct feedback from the instructor of the course, their involvement can increase a dynamic to the course that give benefits to all learners. [10, 11]

3.1 Online Course MOOC

A MOOC activity could be asynchronous or scheduled and a resilient structure is dignified because learners can choose their level of participation. A MOOC is typically hosted on easily accessible sites such as a Google site or a blog or wiki. Public announcements of the course are mainly made on academic websites or professional organizations or blogs. By online registering, the open students can get all related information to the course and announcements. [10]

In 2008, Stephen Downes and George Siemens co-taught a first MOOC class. The name of the course was “Connectivism and Connective Knowledge” and it was presented to the 25 students who paid tuition of the course at the University of Manitoba. At the same time the course was as no cost online class for 2,300 students from the general public. Since that time, nearly all MOOCs have been taught in the technology or education area. In year 2011, Jim Groom led a team of instructors in offering “Digital Storytelling” as a free online course to the public at the University of Mary Washington. In the end of year 2011, 100,000 students enrolled in a MOOC at Stanford University which called “Introduction to Artificial Intelligence” and taught by Peter Norvig and Sebastian Thrun. [10]

In order to manage the frequently large student base, instructors occasionally rely on social media tools to foster participatory, collaborative and peer-to-peer learning. This kind of approach gives the benefit of distributing responsibility for teaching all over the class rather than laying it completely on the instructor. Because of various participants

with different ages and locations, the course benefits from a rich diversity of ideas emerge from many cultures, regions and perspectives. [10]

Characteristics of MOOCs include a possibility of an online mode of delivery, online quizzes and assessments, short videos and quizzes and peer and self–assessment. In following their related pedagogical benefits in order are such as efficacy of online learning retrieval learning, mastery learning and enhanced learning through this assessment. Many people take the courses of MOOCs but they simply do not have the opportunity to attend a University in person and meet the instructors or other students face to face. Reasons for that can be lack of access to necessary prerequisite qualifications, geographical access or financial means. [14]

Even for people who have power to choice of either attending universities or undertaking series of MOOCs that could one day represent a degree equivalence, the evidence shows that their experience will not necessarily be any less rich in either case. MOOCs present an opportunity to conduct educational research and examine the potential for use of its elements in on campus settings as a form of blended learning or flipped classroom approach. Whatever the outcomes is, it is for sure that the nature of higher education will have changed dramatically as a result of this phenomenon. [14]

Presently, MOOCs are expanding rapidly and world widely. According to MOOC Course Report in January year 2015, 273 Free Online Courses will start at the beginning of January 2015. These online courses are in Mathematics and Stats, Science, Education and Teaching, Computer Science, Health and Medicine, Business and Management, Humanities, Social Sciences, Art and Design and Engineering areas. [10]

3.2 Differences between Online Course and MOOC

An e-learning course uses an e-learning platform (LMS) with a set number of and structure and functions which are designed for interaction with lecturers. In order to access to an e-learning course, there is a need the payment of the registration fee. An e-learning course is closed environment. An e-learning course is for restricted team. An e-learning course supports education staff. An e-learning course emphasis on the official certification and the evaluation of the learners of the courses. An e-learning course communications is just through discussion forum. [12]

MOOC is a technological design which makes easy the dissemination of the activity of the participants of the course through one or more platforms. MOOC has an open environment and a free access. MOOC is for the tremendous practitioners. MOOC supports the society. MOOC emphasis on learning process rather than the official certification and the evaluation of the learners. MOOC has assortment communications and MOOC uses of the social networks. [12]

3.3 Advantages and Disadvantages of MOOC

MOOC is a fascinating model which presents many opportunities and challenges not only for students but also for instructors. Because it shapes up all the time, the methods and the expectations of presentation will be more encapsulated, consistent and predictable. A MOOC has potential to amend relationship between the instructors and the learners. By having forums and blogs it generates a wide area for encountering different ideas around the globe. [10]

Another advantage of MOOC is that a MOOC can be organized in any language which the target audience desire. The learners can use any online tools which are relevant to their target region or which are already being used by the participants. Learning happens in a more relaxed setting in MOOCs. Learning can also happen accidentally. It happens when the participants of the course start to exchange notes on the course study and in following some unknown knowledge appears. [13]

A MOOC has possible downsides as well. It makes some students concerned, especially those students who expect an active contact with the instructor. A MOOC can overload some students because of numerous information which streams constantly from discussion boards and any online sources. Features of a MOOC offer a lot of opportunities for the students. But in other hand a MOOC gets sensitive to improper behaviour when the student does not have any economical input in the course. In another hand the instructors should rebuild at least some of the component of a course, consider again the technical logistics and the structural demands of the course. [10]

Among other MOOC criticisms is that a MOOC trots out a new networking method and new knowledge. In general, when new things get tested, they will always bring up satisfactory and unsatisfactory things. [13] In my opinion advantages and disadvantages of

a MOOC are similar with benefits and drawbacks of e-learning. Here are some of the advantages of a MOOC.

A MOOC supports career advancement and preparation of the learners. Corporations need the help of MOOCs for educating their employees and started to have collaboration with creating MOOCs as well. The learners do not need a degree to follow the course. Only the readiness to learn is enough. By participating in a MOOC, the learners can add to their own personal learning environment. With participating in a MOOC, the learners start to think about their own learning and knowledge absorption. A MOOC will not necessarily stop once the course will close. [13]

Summarising the most important of the disadvantages of a MOOC, a MOOC definitely requires the digital literacy. A MOOC requires effort and time from the participants. A MOOC has its own approach and lifespan. The learner can Drop out the course easily. A MOOC can cause a chaotic environment which is unfamiliar for the participants. The course may or may not have instructor(s) and it is possible that sometimes the instructor(s) cannot answer all the questions of the all learners or it is difficult for the learners to know to whom to turn to when comes a problem or question. [13]

3.4 Mobile Learning and MOOC

Mobile access and massive open online courses (MOOCs) have become a global reality. Mobile learning (Mlearning) as well as MOOCs is based on similar characteristics. They both improve increasing of the networking, a community feeling and collaboration. They use the social media in a large scale and they are ideal for the setting up of the communicative dialogues. That dialogue is an important element for learning and knowledge improvement and mobile access increases the opportunities to enter into these interactions. Opening up a MOOC for mobile access has instant impact on the interactions of the learners. Participants with mobile devices tend to interact more with the other learners in comparison to their non-mobile colleagues. There are very important mobile related strategies in order to increase the interactions of the learners in MOOCs in the areas such as designing, self-directed learning, digital skills, content, human learning environment and course activities. Here the 20 mobile related strategies to increase the interactions of the learner(s) in MOOCs are presented one by one. [15]

These strategies offer a ubiquitous learning environment. These strategies create a user-friendly learning environment. These strategies provide self-directed learning strategies to the learners. These strategies enable immediate access to the content of the material. These strategies offer asynchronous and synchronous learner activities. These strategies provide a clear timetable of the course. These strategies allow the increasing of the embed info in the course. These strategies increase the necessary digital skills for the learner. These strategies offer an array of course materials. These strategies provide a sense of ownership about the content and the learning. These strategies ensure a safe learning environment. These strategies provide interaction and communication guidelines. These strategies profile a central course person(s). These strategies watch over the group-size. These strategies allow networks to emerge. These strategies add other activities to the intellectual topics in order to allowing learner interactions to take off. These strategies ensure discussions or conversation starters. These strategies create meaningful, contextualized and generic and topic related interactions. These strategies add activities involving non-verbal communication to offer additional understanding. These strategies ensure topic relevant learner diversity in examples or actions. [15]

3.5 Current Problems of MOOC

The major problems of MOOC at this moment are such as there is not face to face teaching in MOOC and the credibility of MOOC should be improved in areas such as tests, assignments, final examination, receiving of the participants' certificate, the quality of teaching of the MOOC should be fully protected. [16]

The number of participants of the MOOC is so huge and in order to make all the participants, there is need for strong strategies in teaching methods, supervision and ensure the quality of teaching. The evaluation criteria of MOOC should be specific. Especially final assessment should be standardized, MOOC has large-scale of the participations around the world and there are not problems such as time and place. [16]

But MOOC cannot achieve the "individualized". In MOOC manufacture of large quantities will reduce the characteristics of the development of individuals and innovations, the capacity and quality of education in MOOC should be improved. By developing the capacity and quality of education, MOOC will be more completed and there is an urgent need to break the limitations of the language of instruction. At this time current

MOOC courses are mostly in English language and many students cannot speak English language. [16]

3.6 Recommendations and Future for MOOC

Various teachers, professors and instructors from different organizations are trying to improve MOOC. Here are recommendations to improve. Each video should not be longer than 10 minutes. Studies have shown that human s mind declines and loses interest; teacher-student interaction should be increased and gotten stronger. [17]

So, the teacher does not lose interest and the student enjoy from teaching effectiveness, continuous suggestions, positive improvements, feedback and actively collecting feedback make the education system more perfect, increasing financial support for MOOC in order to make strong development and strong infrastructure construction, breaking the traditional limitation and improve technical operations. [17]

In the future, MOOC offers an alternative and acceptable technique of delivering the knowledge. The reasons for this are such as the inability of colleges and universities to meet the global demands for higher education, the ‘digital native’ of today and tomorrow is the reason for demanding of the using more technology in education, according to the newest research, the students of MOOCs are satisfied with the qualification of MOOCs. The Education Center for Analysis and Research reports that 57.7% of students have said that they learn more in courses which have online component. Currently all of MOOCs are not free. Currently MOOCs are centered more on universities and colleges. [18]

Some critics believe that MOOCs are passing fast. Their argument is based on reasons such as the high rate of the students who dropout the course, the exclusion of the learners who are without online access, the high potential for cheating, the poor engagement of weaker learners, the high potential for plagiarism and for fostering a system of global ‘sameness’ in higher education learning. Stanford professor Susan Holmes wrote, “I don’t think you can get a Stanford education online, just as I don’t think Facebook gives you a social life”. Currently producing MOOCs requires more than hundred hours work, 25,000 US dollars and technical and tutorial support. With these features only the most affluent schools can afford to engage in MOOC development and delivery. [18]

MOOC providers could also be providers for the other universities with the ability to license their courses. MOOCs deliver the opportunity to ‘democratize’ higher education by permitting the students and the adult learners to participate in any course through an elite University while they are remaining in their own countries. Currently MOOCs have the potential to reach two billion potential learners. MOOCs have the ability to build global learning communities by expanding access to disenfranchised students. Probably the most magnificent potential for MOOCs is the connecting of MOOC ‘graduates’ to the future employers. [18]

One issue of MOOC delivery which is not being discussed is the potential impact of MOOCs on higher education administrators. If MOOCs will be a mainstream higher education delivery method, the administrative work life of the chief financial officers, the registrars, the admission officers, the student service deans, the career counselors, the facilities directors and the alumni directors will totally change. [18]

4 Platforms for Massive Open Online Course (MOOC)

According to the votes in the Mooc lab, the most important MOOC platforms are EdX, Coursera, Udacity and other important MOOC platforms are Alison, Canvas Network, FutureLearn, Iversity, OpenLearning, Open2Study, and Udemy. [19] Below an overview of these platforms as a basis for selecting the most appropriate one for the current project.

4.1 EdX

Harvard University and Massachusetts Institute of Technology established a massive open online course (MOOC) platform in May 2012 which called EdX. These two institutions have each contributed $30 million of resources to this non-profit project. EdX offers online University-level courses in an expansive area of disciplines to a worldwide audience. The first prototype online course which was Circuits and Electronics, started through MITx in December 2011. At this moment EdX had almost 2.5 million users in July 2014 according to CEO of EdX Anant Agarwal. EdX is making empowering learning not only in the classroom but also on the world. [20]

The main goal of EdX is not just offering courses and content. The researchers, innovators and experimenters of EdX want to understand how students learn, how technology can transform learning, and the ways teachers teach on campus and beyond. Then at the same time they we want to share everything that they discovered. [20]

The EdX platform is an open source and it is available for everyone. The researchers, innovators and experimenters of the EdX publish researches on how students learn in order to enthuse and empower all educators around the world and advance success in education. The most important principles of the EdX are collaborative, financially sustainable, nonprofit and open source platform. General purposes of the EdX goals are such as expanding access to education for everyone around the globe, extending learning and teaching online on campus or out of campus and researching for improve teaching and learning. The EdX has connected many educational institutions around the globe. In January 2014, there were 30 institutions which are involved in the EdX. In 10.11.2015 the EdX 552 Verified courses which 247 of them are currently running. [20]

4.2 Coursera

Computer science professors Daphne Koller and Andrew Ng founded Coursera which is educational technology company and offers massive open online courses (MOOCs) from Stanford University. Coursera is an educational platform that associates with top organizations and universities and world widely and offers online Courses are open to anyone in anywhere. [21]

Coursera has four key ideas which have strong influence in modifying of the vision of the learners. These four key ideas are Blended learning, Effectiveness of online learning, Peer assessments and Mastery learning. The blended model of learning in Coursera has been certified in studies to increase the learners' attendance, engagement and performance. Online learning has a new significant role in a lifetime education. A recent report by the U.S. Department of Education found that "classes with online learning (whether taught completely online or blended) on average produce stronger student learning outcomes than do classes with solely face-to-face instruction." [21]

Coursera utilizes peer assessments. So the learners can evaluate and generate feedback on each other's work. In many studies, this technique has been very effective. Because not only it gives accurate feedback for the learner but also it is valuable learning experience for the grader. [22] Coursera works with different universities in different countries to make some of their courses available online. In January 2015 Coursera has 892 courses from 117 partners. [21]

Coursera has several international partners all over the world. [23] The courses of Coursera are in different areas such as Physics, Social Sciences, Statistics and Data Analysis and Teacher Professional Development. [24]

4.3 Udacity

Udacity is an educational organization which is a for-profit. Udacity founded by Sebastian Thrun, Mike Sokolsky and David Stevens. It offers massive open online courses (MOOCs). The root of the name Udacity comes from "audacious for you, the student".

[25][26] Before Udacity was offering University-style courses. But now it focuses more on vocational courses for professionals. In year 2011 Stanford University offered free computer science classes and Udacity was spin-off of that. [27]

The investors of Udacity are venture capital firm, Charles River Ventures, Thrun Sebastian. [28] In April 2014, Udacity had 1.6 million users in 12 courses and 26 free coursewares. [29] In year 2014 Georgia Institute of Technology launched the first massive online open degree in computer science for $7000 by associating with AT&T and Udacity. Udacity and Georgia Institute of Technology started to develop new model for higher education. [30] [31]

Udacity has different courses in various areas such as Data Science, Software Engineering, iOS and Android. The skill levels of these courses are for the learners who are in various level of learning such as new To Technology, beginner, intermediate and advanced. [30] In February year 2012 Udacity launched two first courses. The first name was Building a Search Engine and the second was Programming a Robotic Car. [31]

In April year 2012 Udacity launched four other courses. After that In May 2012 Udacity for first time announced that it will offer five new courses which are not in computer science area. [32] In early year 2013, Udacity launched Computer Science Courses. Udacity made these courses in collaboration with Google, Microsoft, Nvidia, Cadence Design Systems, Autodesk and Wolfram Research. [33] In January year 2013 Udacity and with San Jose State University (SJSU) start to have partnership. They made three new pilot courses in statistics and algebra. [34][35]

They expanded this partnership by making other new pilot courses. But this partnership was suspended. The reason was failing of the half of students in their final exams.[34] In year 2014, Udacity and AT&T start to have partnership in order to make "Nanodegree" program. The aim was to teach programming skills for people who need to be qualified for an entry-level IT position at AT&T. [36] [37]

4.4 Other Important Platforms for MOOC

Udemy is longtime participant in the online learning area. It is skills-based for commercial dealings where private teachers can sell their skills and both free and paid learners

can have access to courses. The founders of Udemy are Eren Bali, Gagan Biyani and Oktay Caglar. Udemy is a marketing arena where skilled private teachers can build and upload courses. In addition, it provides tools for building courses. One of the pinpoints of Udemy is various enterprises to whose personnel Udemy offers different. [38]

Udemy is going to expand in markets outside the United States. According to CEO Dennis Yang Udemy constantly developed. The courses and the course creation tools of Udemy are all the time under development. [38]

Founders of Udemy are trying to make the availability of Udemy as wide as it is possible. They want to make sure that integration with their core experience is possible as well. It may be in the future to the TV as well. Countries of interested to Udemy are in West European, e.g. the U.K., Spain and Germany, along with Brazil and Japan. [17] Udemy has various courses in areas such as development, business, ICT, software, marketing, health, language. [39]

Iversity is the European platform which is for online learning. It enables universities to share a wide range of various courses with students from around the world. It provides them with the occasion to gain recognised letter of credence, wherever the students geographically are. Iversity has intensive collaboration with various higher education institutions, instructors and knowledge-based companies in order to generate high-quality courses that are interactive and engaging. These online courses are called MOOCs and they offer opportunities for the professors and students alike. These MOOCs allows the professors to experiment with innovatory teaching methods and generate a customised higher education experience not only for students but also for independent learners. The goal of Iversity is making empower environment for the academic areas and helping the universities, not replacing them. [40][41]

The founder of Iversity is Jonas Liepmann. He founded Iversity as a student and his aim was publication and facilitates networking within academia. He made secure the funding of Iversity by the“EXIST”-programme which was a government scholarship for aspiring student entrepreneurs. In year 2011 he brought Hannes Klöpper on board. Then these two started to continue developing of Iversity together. In year 2013, Jonas Liepmann reaches the CEO position and as a shareholder of Iversity Jonas Liepmann continues to be involved in the advancement of digital learning. [40] The courses of

Iversity in January year 2015 were Business Analysis, Game design and development, Stonehenge, Human rights and Political philosophy. [41]

Since Iversity was made in Europe; it specialized in working within the current judicial and administrative infrastructure and particularly the European Credit Transfer and Accumulation System (ECTS). Some of the partner institutions of Iversity already grant ECTS credits to online learners taking their courses on Iversity platform. Iversity creates higher education more accessible, more personalised and more affordable. Iversity believes in the transformative power of online education. Both the team of Iversity and its online learning community are multifaceted. Iversity introduces intellectual Iversity, by gathering various educated people in various areas. These people are graduates e.g. in Philosophy, Physics, software programming, Political Science and even entrepreneurs. They studied and lived all over the world and have experienced in various learning cultures, different education systems and institutional settings. The team of Iversity has cultural sensitivity and "passionate commitment". The aim of this team is to bringing higher education into the digital age. Iversity optimises its didactical methods and technology in order to deliver the best possible online education experience. It practices what it teaches i.e. lifelong learning. [40][41]

OpenLearning is a for-profit educational technology enterprise. It offers a social online learning platform which delivers massive open online courses (MOOCs). Open Learning uses new online learning software. The founders of OpenLearning are software engineer Adam Brimo and Professor Richard Buckland from the University of New South Wales. OpenLearning learning software varies from the systems used by other MOOCs such as Coursera. [42]

OpenLearning creates an online learning community by integrating social networking and the other collaborative features. The Platform of OpenLearning allows the students to collaborate in studying the material, posting comments, making notes and ask questions from each other. According to professor Buckland, his students at University of New South Wales (UNSW) who had used a beta version of the software in their computing courses, learnt through their online collaboration. New version of OpenLearning permits anyone to build a course without any cost and the course is available freely. But the builder of the course wants to restrict access to a particular group, then OpenLearning charges a fee per student. OpenLearning’s software could also work as an

organisation's learning management system. Because it is cloud-hosted, it does not require investment in the servers or the other hardware. [42]

OpenLearning has collaboration with the Taylor's University and University of New South Wales in order to deliver the first MOOCs in Malaysia and Australia correspondingly. [33] In year 2013 OpenLearning launched a cloud based software product for various companies to make private educational portals on its platform. OpenLearning provides courses in different areas such as and economics, computers and technology, engineering, health and medicine, language and Communication. [43]

Canvas Network is a massive open online course platform which is developed by Instructure Company. Instructure is an educational technology company and it is in Utah, United States. Instructure developed the Canvas learning management system, which is a broad cloud-native software package which has competition with systems such as Desire2Learn, the Blackboard Learning System, Moodle and the Sakai Project. In year 2008 Instructure was founded by Devlin Daley and Brian Whitmer who graduated from Brigham Young University (BYU). But initial funders are Epic Ventures and Josh Coates. [44]

Canvas Network offers open, online courses which are made by professional educators. It generates a platform and place where students, teachers and institutions can connect world widely and can their course for personal growth, professional progress and academic inquiry. Canvas Network provides various facilities and functionalities for Canvas which is the learning management system and makes teaching and learning easier for more than 12 million higher educations (K-12). The structure the Canvas is adaptable, reliable, open, native cloud technologies that empower learning in any context. [44] Canvas Network provides courses in different areas such as Computers and Technology, applied sciences and medical science. Many Universities and colleges use Canvas Network around the globe. [45]

ALISON is a global social enterprise which provides certified, essential, education and workplace training skills free through e-learning to any individual in anywhere around the globe. Serial entrepreneur Mike Feerick who is global leader and innovator founded ALISON in year 2007 in Galway, Ireland. In year 2014, ALISON has had 4 million learners in 200 countries. According to ALISON, in year 2007, 400,000 people graduated from ALISON courses and they received free certificate and diploma courses. In

year 2007 the United Nations Educational, Scientific and Cultural Organization (UNESCO) recognized the contribution of ALISON with the Award for Innovation in ICT in Education globally. In year 2013 the World Summit for Education recognized the contribution of ALISON with the Award for "outstanding quality and exceptional impact on education through innovation." [46]

ALISON has many statements and messages for learners such as the success of the learners is the success of ALISON, by helping of the learners and the supporters, ALISON tries to, help people to educate themselves for free, provide a better service every day and spread the word about free learning in various local community. ALISON believes certifiable, standards-based learning which can be made available for every subject and it is online, free and especially marginalized people in the developing. [50] Alison courses are in areas such as technology, engineering, ICT, languages, economics, medicines and arts. [47] The publishers of ALISON are various freelancers, entrepreneurs, universities and companies such as Google, Microsoft, Harvard and Stanford University. [48]

FutureLearn is a massive open online course (MOOC) e-learning platform. It was founded in year 2012 as a company owned by The Open University in Milton Keynes, England. FutureLearn is the first UK-led massive open online course e-learning platform and has many partners not only in England but also in other countries. [49] The partners of FutureLearn around the globe are such as University of Auckland in New Zealand, University of Cape Town in South Africa, Fudan University in China, University of Groningen in Netherlands and University of Liverpool in England. [51] The courses of FutureLearn are in various areas such as business and management, arts, health, languages, science, math and technology. [52]

FutureLearn provides a powerful and new way to learn various subjects in online. Every course has been designed according to principles of effective learning, discussion, visible learning, storytelling, and using community support to celebrate progress. Each partner University of FutureLearn has designed a course with complete learning experience which is presented by leading academics in their field. Ideas are introduced via high quality articles and videos. Then the learners can discuss what they have learned; test their new knowledge with interactive quizzes which offer helpful responses and the opportunity to try again if an answer is wrong. Every course step by step tells a story

with challenges and supportive tips along the way, to test and build the understanding of the learners.

FutureLearn enables the learners to share and debate ideas with other learners, to understand their different perspectives, experiences and to fill the gaps in their knowledge. Because not every learner likes being social, so rather than sending the learners off to separate discussion forums, the learners can add their comments alongside the content. In discussion forums the learners can start by reading what other learners have to say about the topic, and then join in when the learners are ready. If the learners like a comment particularly, they can choose to follow its author so that they can easily find the comments and people that are of the most interest to them. With this method social learning is not felt like a forced conversation and it is been felt like a chat with friends where friends change their ideas and tell to each other what they have learned. The To Do list gives the students an overview of the course, showing the activities for each week, and keeping a record of what they have completed. FutureLearn has many important features such as the visible learning and the community support model. The visible learning is inspired by the work of John Hattie and the community support model comes from Diana Laurillard's work on conversational frameworks for formal learning. [50]

Open2Study founded in Australia by open Universities Australia. Open2Study was launched in March 2013 and it is a learning, teaching, and assessment platform. It enables universities to offer free online courses. [53][54] Paul Wappett is Chief Executive Officer of Open Universities Australia. [55]

The courses in Open2Study all are free All of the subjects are available to everyone anywhere. The courses of Open2Study are in high-quality education and free of charge. When the learners successfully complete their subject, they receive a Certificate of Achievement, which they can use to demonstrate their interest in learning about a certain area. The learning platform of Open2Study consists of weekly modules, which are completed over a four-week period which consists of online assessments. These assessments are at the end of each of these modules. They are in multiple choice tests and these tests can be repeated four times if the students fail. In order to receive a Certificate of Completion of the course the student must gain at least 60% score of these online multiple choice assessments. Open2Study has many courses in various areas such as business, medicine, marketing, art, management, science, technology, languages, and engineering. [54]

Moodle (modular object-oriented dynamic learning environment) is an open source learning management system such as the EdX. Moodle is used in many universities around the globe. Moodle is used in Metropolia as well. Moodle can be used as independent application system. Moodle it can operate without integrating to the other applications or services. [56]

The most important features of Moodle are such as new content can be created, edited and upload to the platform, in Moodle, the instructor can upload any files and the users can download the files easily, in Moodle there is an instant messaging system, making an online quiz is possible in Moodle, Moodle can be used to deliver the online exams, assignments can be submitted to Moodle easily, self-evaluations and self-testing are possible in Moodle, Moodle generates the grade to the students, by using Moodle it is easy and fast to gather feedback from the users of the course, Moodle has discussion forum and it can record and extend them, in Moodle announcements and news can be made and updated, Moodle also has a course calendar. [56]

4.5 Comparing EdX, Coursera, Udacity and Moodle

According to the present research, the best online platforms for Universities and Universities of Applied Sciences are EdX, courser, Udacity and Moodle. In the following, I describe the benefits and the drawbacks of EdX, courser, Udacity are described one by one and in the end there is comparision of EdX and Moodle. Here are the benefits of using EdX.

EdX has a large catalog from interesting and prestigious University partners. EdX has some foreign language classes and a great online platform for teaching the sciences and the medicine. EdX has free unverified certificates, free “honor system” certificates, advanced certificates for specialized work and fee-based verified certificates. [60] In my opinion the best thing in EdX is that, EdX is an open source and any University, firm or normal user can modify it for its own needs but being open source will make an issue as well. [57] The drawbacks of using EdX include: EdX has frustrating discussion forums. EdX is more variance in quality. EdX does not have apps at this moment. Because EdX is open source, its developing will take time. [57]

Using of Coursera has many benefits. Coursera has largest catalog among other online platforms. Coursera has very brilliant discussion forums by comparison. Coursera has transcripts in a large number of various languages. Coursera has the superlative strain of the partners around the globe. Coursera has iOS, Android and Kindle Fire apps. Coursera has free unverified certificates of graduation. Coursera has free “honor system” certificates, advanced certificates for specialized work and fee-based verified certificates. [57] The drawbacks of using courser include: the learners of the courses might have to wait in a while until the wanted course will be activated. Coursera is structured and it makes it difficult for some learners. The learners should follow the pace of the releases of the instructors such as the videos and assignments. Coursera has more variety in quality. Coursera is not open source. [57]

Next, the benefits of using Udacity. The courses of Udacity start anytime and the learners should not wait for the wanted course. Udacity has a lot of programming and computer science courses. The courses of Udacity focus more on current workplace skills. Udacity has iOS and Android app. The courses of Udacity move the pace of the learners of the courses. [57] The drawbacks of using Udacity include: Udacity has smaller community and the learners mostly are working on their own unless they pay for the premium version of their course. Udacity is difficult if the learners of the courses need deadlines to keep them on track. Udacity has little courses in foreign languages. Udacity does not have free certificates anymore. Udacity is not open source. [57]

In my opinion, Moodle is a very valuable platform. But the navigation of Moodle is intractable. Moodle is overall tool, there are too many things and it can operate in nearly in every situation. So, just the expertise of the teacher can make the course pleasant for the students. So, the teacher should have good experiences and expertise about Moodle.

Finally, Tricider which is web based polling and thinking tank tool has a thread to Moodle. In Tricider the users can post comments about Moodle. According to Tricider posted comments Moodle cannot support the students stronger than the other virtual learning environments. [20] [57] [58]

Summing up, EdX is a newly introduced learning management system. The EdX leads up to higher number of participants comparing to Moodle. The EdX has attractive features such as analytical evaluations and results. The major advantage of the EdX over

Moodle is its graphical user interface. The EdX has attractive interface which follows up the responsive web design pattern. The EdX ascends precisely in various types of media devices ranging from small screen mobile devices to large screen desktop. In addition, I have to say that the most important thing in choosing the platform is to know which platform meets our requirements better. [20] [57] [58]

5 Overview of EdX

Open EdX is a platform which is based on web. It creates, delivers, and analyses online courses. It is the software that runs EdX.org online education sites. The current architecture of the open EdX platform is described here on a general level. The parts in need of change are also introduced and explained.

5.1 Technologies of Open EdX

The technology used in the server-side of the open EdX is in Python and the technology used in the application framework is Django. Mainly the browser-side code is done by JavaScript. Part of the code was written in CoffeeScript before and now EdX is replacing that code with JavaScript. Some parts of the client-side code use the Backbone.js framework. But EdX is trying to change more of the code base into use that framework. Open EdX exploits Sass and the Bourbon framework for CSS code. Other softwares used in creation of open EdX are NodeJS, Ruby, Ruby on Rails and Java. There is an alternative to Python which is in progress. Another problem is that the Python Django apps are not just Django. The exercises and the content of open EdX are written in XML and HTML as scripting languages. [59]

Open EdX consists of multiple components. These components are defined and planed based on the service architecture of the open EdX. The current components are getting updated and upgraded. It is possible that in the future some other components will be added to these components. The major components for running open EdX are CMS, LMS, cs_comments_service, MongoDB and Relational Database (MySQL). Optional components are for running open EdX are XQueue Service, XServer, EdX ORA, Discern, EASE, edinsights and notifier. Other components for running open EdX are XBlock, event tracking, configuration and CodeJail. [59]

The most important elements of open EdX created by open EdX components are studio, course browsing, course structure, discussion, mobile apps, analytics, background work and searching. The EdX offers an effective and elementary way to select online courses. This system contains two groups of users which are the instructors and the learners. This system also offers the provision of certificates for the learners in two dif-

ferent modes; the first one is honored for those who complete the courses. The second is proctored. There are four assessment categories in this system which are staff assessment, peer assessment, AI assessment and instructor assessment. [59]

Developers all over the world are developing EdX by their contributions all the time. The main features of EdX are e.g. discussion forums multilingual support, upload and download the various files with various formats, calendar based schedule, virtual laboratory which provides simulation and supports interactive interface, multilingual support, wiki edits for collaborative learning, the interactive video lectures which can be downloaded, with the subtitles and indexing on the subtitles, online quizzes of various types like video embedded quiz and final tests, supporting the huge number of user participation (scalability) at a specific time, registering and deregistering facilities for a course, progress reports and analytics in different formats like bars and charts, EdX meet-ups - online conferences, provision of certificates in two ways; honor and proctored, notifications and emails for the users of EdX, different models of the assessment systems for submitting the assignments (open response questions) which are staff grading, self-grading, machine grading and peer grading. [61]

5.2 Technology of EdX Course

EdX courses are built by xblock pieces. By combining xblocks from various sources, the author of the EdX course can create valuable and attractive course. Xblock can represent small pieces such as a text, a video, an input field or a multiple-choice. It can represent large pieces such as a unit, a section a chapter, or a complete course. Of course, xblocks are not just for delivering EdX courses. Xblocks can be recycled over the various courses and distributed in the community of EdX. They can also provide components for making applications. [60]

There are different xblocks for EdX courses. These xblocks are such as adventure xblock which creates an elementary "Chose Your Own Adventure" style simulation. Brightcove video xblock which includes brightcove videos in an EdX course.

ORA2 xblock is version two of the open response assessor project. This xblock generates functionality for all assessments. Drag and drop xblock which asks the learners to drag and drop the image(s) or the text(s) into different pails according to the content of the course. Leader board xblock which allows to display an incidental number of top

scoring threads in an online discussion. Image explorer xblock which shows tooltips on top of an image in the course content. [60]

Audio xblock makes audio for the learners of the course. ACID xblock is a block for testing the implementation of the xblock runtime. 3D Model Viewer Xblock: which include and view 3D object models in a course. Animation xblock displays to the learners an animation. Carousel xblock which provides carousel of multimedia instructional content, including video, images, and documents. This xblock generally supports three different web hosted media formats in a unified media carousel for the course content presentation. Poll and survey xblock is survey/poll method that course author uses to receive feedback of her/his course participants. Poll Xblock includes one question, and a series of answers. Survey Xblocks have several questions. Staff graded assignment Allows the learners to upload files that can be graded by the course staff. School yourself which repository consists of xblocks for displaying school yourself (SY) content in the EdX platform. [60]

Staff graded assignment allows the learners to upload files that can be graded by the course staff. Table Xblock is a powerful tool. It is used for edit tables. Pie Chart Xblock which includes Pie chart in an EdX course. Video JS xblock: Use Video.js HTML5 player (www.videojs.com) in place of the default player. Google drive xblock which makes possible embedding of the google documents or google calendar in EdX. Drag and drop xblock v2 which is improved from the version of the image explorer xblock. Flash xblock which is embed flash (software) files into the course. [60]

PDF xblock embed PDF into the course. Ooyala video player xblock includes ooyala videos within an EdX course. It supports transcripts, overlays (which set html content or straight text at a specific moment in the video) and player tokens (which secures the video content by using a token with an expiration time). Problem builder xblock is set of interactive tools and exercises in order to automate the workflow of real-life mentoring in a course. It supports free-form answers. Carousel workspace xblock combines learning content and practice space within the same window. Mathematica Cdf Xblock which is used to visualize .cdf (mathematica) files in EdX course. Paella video xblock which permits the use of stored videos in a matterhorn server by using paella player. [60]

Finally, *experimental xblocks* are group project xblock which allows the learners to work as a group of two to five persons on a group project and discussion xblock is a

prototype of the discussion xmodule as a separate, pure xblock. It requires patches which EdX-platform at present. [60]

5.3 EdX Main and Extra Modules and Their Functionalities

In the EdX system, there are some two different modules which exist along with LMS and CMS. These two modules are improved independently and integrated with EdX-platform. These modules are hidden into two classes which called main modules and extra modules. The main modules are required to make a complete EdX system. Extra modules are required to improve the functionality of EdX system. [62]

The main modules of EdX cosists of EdX-platform, xserver, EdX-ORA, xqueque, cs comment service and codejail. EdX code is found on Github website. These all modules can be entried on Github and everyone can contribute to improve the EdX. EdX-platform is main module of EdX system. It includes CMS and LMS to shape a basic and initial system. Xqueue generates an interface between the external grading system and LMS. Codejail protects the system from external user. This module generates the security by creating a sandbox which executes the not trusted code from the users. Cs_comments_service provides the discussion forums for the users. EdX-ORA allows instructor, peer and machine assessment of problems on the EdX-platform. ORA stands for “Open Response Assessor”. Xserver accepts code from the users of LMS and executes them by using the courseware graders. [62]

The extra modules are developed to improve the EdX functionality. The extra modules are ed-insights, EdXanalytics, EASE, djeventstream, loghandlersplus and discern. Discern generates services for the grade arbitrary and free text responses from the system. Ed-insights offers a framework for improving of analytics platform. EdXanalytics runs analytics on EdX data and provides meaningful statistics. This analytics platform is built based on the ed-insights module. Ease generates the grading machine of the open responseanswers. Ease means enhanced artificial intelligence scoring engine. Xblock generates component architecture for building courseware. Djeventstream takes the log events from the loghandlersplus module and provides appropriate Django signals for the EdXanalytics. Loghandlersplus performs some functions on the log file from LMS and generates the log events to the EdX analytics module. Apart from all these modules, there are other modules which are presented on the Github website and they are under development stage. [62]

5.4 EdX-platform and Its Components

The main module in EdX is the EdX-platform. It consists of three major components. These components are LMS, studio and CMS. LMS means learning management system and CMS means course management system. The LMS provides an interface for the learners to select MOOC courses. Studio is the course online authoring tool of the EdX platform. CMS generates an interface for instructors to create and manage the courses. [63] In previous chapters the basics of LMS and CMS was explained. This chapter explains LMS, studio and CMS in EdX platform briefly

In the EdX platform LMS is built based on the django framework. LMS basically generates an interface to the learners to register and choose MOOC courses and an interface to the instructors to build and admin MOOC courses. [63]

LMS of EdX is built based on the django framework. LMS of EdX has brilliant features. LMS of EdX makes online tests, quizzes, assignments and discussion groups for the students. LMS of EdX makes self-paced learning enable. LMS of EdX can build circuit schematics for various experiments. LMS of EdX can build machine for essay assessments and peer grading. LMS of EdX saves the study sessions of the students in a log file for further study automatically. LMS of EdX gives the opportunity to the students to register and unregister into the courses at any time. LMS of EdX gives the opportunity to the student to see the total number of the participants of a course. LMS of EdX sends recommended courses to the learners in real time. LMS of EdX has strong search machine for searching the courses. [63]

In EdX platform, Studio is the course online authoring tool. By using studio the instructor can create and make changes to a course(s) of EdX. The learners can see everything (in the course) what the instructor builds on LMS. In additional, after creating and making changes to a course(s) the instructor should select the View Live button in Studio and then immediately the learners will have access to a course(s) in the LMS. [63]

Studio online editor has a simple hierarchy of sections and subsections to create and organize the content of the online course. Simple drag and drop tools of the Studio online editor makes to reorganize the content of the online course fast. It builds and releases sections to the students of the online course incrementally. It reinforces learn-

ing, because with just a few clicks the students of the online course can see videos, discussions and exercises. It helps the students to understand one concept at a time with HTML, multimedia, and exercises. It has a broad library of different problem types. [64]

CMS of EdX platform generates different features to make the instructor(s) work easier. CMS of EdX allows adding various types of contents for the course creation. All the functionality of CMS of EdX are online. CMS of EdX has features such as the live view, the course updates, the grading policy, uploading static pages. CMS of EdX can import and export the course(s). CMS of EdX can create various assignments which contains various responses. CMS of EdX gives opportunity to the instructor of a course add the other studio user in a course team for co-authoring the course. [65]

EdX publishes its roadmap publicly on the Open EdX wiki, so that the customers of EdX can predict, design for, and provide feedback on the product direction and investments of EdX. This roadmap provides high-level objectives goals and goals as well as specific features that will be expected to deliver in during of next 3 months. The roadmap is divided in areas such as teaching and learning tools, mobile, open EdX and platform investments, EdX.org, professional education and data and analytics. [67]

5.4.1 Teaching and Learning Tools in EdX

EdX is elaborating and improving tools for its partners to generate, educate and organize their courses, the experiences of the learners and the learning outcomes. The EdX's aim is to expand the instructors and the learners' satisfaction by revealing constant incremental progress on the workflows and the tools. The EdX is concentrating on the developments that deduct the cost and the time for building and running courses. It is also concentrating on adding new functionalities that permit richer experiences in EdX courses. [67]

The product areas in the teaching and learning tools are such as Studio, LMS, Discussion Forums and Instructor Dashboard. According to the EdX roadmap created by Victor Shnayder on Oct 22, 2014, Studio publishing reforms for the course authors to simplify releasing and updating courses and full Studio GUI interface for authoring peer and self open response assessments features are released. The navigation and the moderation improvements discussion forums and creating the private cohorts for dis-

cussion forums for the private discussions features are in progress. Creating features such as versioning support in Studio, improved grading and group work will be done in the future. [67]

The important features of the EdX such as offering donation after sign up or course completion, tracking Selection reforms to simplify course enrollment, course discovery reforms to permit the learners to search easily and browse courses and enabling login and registration to EdX.org using third party authentication mechanisms such as Facebook or Google are released. [67]

Finally, the EdX is providing for its partners professional courses for occupational process and career promotion while managing their own mark and marketing through a white-label hosted solution. The EdX invests in the registration and the payment that give opportunity to the professionals and their employers in order to buying classes in their business environments. Feature such as branding and theming support for Professional the EdX offerings, bulk purchasing of the courses for the organizations and reporting capabilities for marketing and accounting are planned for the future. Feature such as branding and marketing management system will be created in the future. [67]

5.4.2 Data and Analytics

The EdX is increasing the capability of data visibility and analysis for its customers, with particular concentrating for the course period on the course teams, the instructors and the researchers. For course instructors and teams, the EdX releases an Analytics Dashboard to widely expand optics into the learners' demographics, conduct and efficiency. For researchers, the EdX continues to elaborate the analytics platform to create data track able. For the Open EdX community, the EdX opens its source, code and work to prop up contributions of the new analyses and the reports. [67]

Product areas in the Data and Analytics are such as Raw Data Packages, Analytics Dashboard for Instructors. Features such as the first mobile app of the EdX later this year, instructor analytics dashboard and enabling downloads of only the new data each day are released. Feature such as Report Data APIs that can be used to programmatically access the data available in the dashboard and ask the community for feedback is in progress. Features such as continued API enhancements and expanding collection

of out-of-box reports for the teachers and the instructors will be created in the future. [67]

5.5 Open EdX and Future Developments

Open EdX, the community of EdX platform and features of open EdX are described here on a general level. EdX in Mobile devices, public and private versions of the EdX and latest release of EdX on 27 October year 2015 are also introduced and explained here shortly.

5.5.1 Open EdX

The EdX is encouraging the developments of the community of the EdX platform contributors to run innovation in the learning and the teaching. The EdX is improving an ecosystem of suppliers and consumers who aid the community of the EdX. The EdX opens communications channels to provide transparency on its education and leads on the integration points and best practices. This initiative also entails continued engineering investments in core platform capabilities to ensure efficiency, extensibility and scalability. Product areas in the Open EdX and Platform Investments are such as Core platform and API. [67]

Features such as designing Open EdX Conference, documentation and publishing public interfaces of the EdX in XML and APIs, Creating public bug list, public roadmap and active product backlog, elaborating the releases and publishing them on a quarterly basis to simplify placements and upgrades of Open EdX instances are released. Features such as enhancing performance and stability of the course and import and export from Studio, introducing theming, enhancing stability and performance of asset delivery within courses, continuing to improve XBlocks, enhancing the stability and the performance of the front end application, launching a Open EdX community Web site for developers, establishing governance model for Open EdX, supporting different features by Open EdX community, moving toward deployable subsystems of the platform independently and continuing to develop APIs for LMS, Data and Analytics, Mobile and Xblocks will be created in the future. [67]

5.5.2 Mobile

EdX is trying to produce and deliver new experiences for mobile device that increase the learner productivity and drive the learner satisfaction and engagement. EdX is concentrating on the native and the companion app experiences that take benefit of the mobile device capabilities, while concurrently it is enabling delicate design on EdX.org for a more seamless transition among devices. Over the long term, EdX will offer imperative and efficient educational experiences on any device for anyone in anywhere at any time. [67]

Product areas in the mobile are such as native mobile apps and responsive UI. Features such as Android Smartphone and native iPhone and apps for the course announcements, the viewing video and the course handouts and improved workflow for managing, transcending and adding video content to courses are in progress. Features such as general availability of Smartphone app, notifications, tablet, groups and assessments will be created in the future. [67]

5.5.3 Public and Private Versions of the EdX (EdX.org and Edge.org)

EdX.org is the main course environment at the EdX. EdX.org is the place where the MOOCs of the EdX live. The EdX partner institutions create the courses for EdX.org. Edge.org is the private course environment at the EdX. The courses which are built on edge.org are not listed on EdX.org publicly. But the learners can have access to these courses with a specific URL which the team of the course provides. This makes edge possible for testing the features of EdX in a controlled environment. Another purpose of edge is that it is private and the partner institutions of EdX can use edge to build blended or residential learning courses with the EdX platform for campus or in person use. These courses are called small private online courses or SPOCs. [66]

EdX is also creating significant reforms to the learners experience on the EdX.org destination site, including a easier registration and course finding process, a clearer track selection flow, a mobile-friendly delicate website and more amiable payment process for the verified certificates worldwide.

5.5.4 Latest Release of EdX on 27 October year 2015

On 27 October year 2015, the researchers of open courseware development platform announced the newest release of EdX Platform on EdX.edge and EdX.org. The newest release of EdX Platform includes the changes such as generating certifications from “Instructor Dashboard” page, setting up the overrides of the course number and information about the Oppia exploration tool. [68]

The learners who generate certifications in their studies can find information about their certificates or download a .csv file of all certificates from the Instructor Dashboard. Oppia is a third-party tool that the builder of EdX course can use to generate brief interactive tutorials. These interactive tutorials called explorations. Set a course number override is optional in building an EdX course. The builder of EdX course can determine an invariant course number to utilize on the certificate of the course. [68]

6 EdX and New Mathematics through Programming Course at Metropolia

This chapter introduces the use of EdX at Metropolia in details, as well as the ICT mathematical applications course in question and the most relevant and pertinent benchmark courses in Coursera and EdX.

6.1 Use of EdX at Metropolia

The Open EdX software is available under an AGPL license. That means that invidual or any organization is free to use the software for any purpose that they want, and they do not need to ask permission to use EdX or pay for that. However, there are still some restrictions, and the biggest one is that they must make their copy of the software open source as well, including any changes they make to it. If they run a website based on the Open EdX software or they build a new feature into the site or change the HTML pages or make any change at all to the source code, then they are legally required to make the source code of their website available to anyone who uses their website in any capacity. (If they run a public-facing website, as many people do, then they source code must be visible to everyone in the world.). [69]

The Open EdX software is freely available under the AGPL, but the courses running on EdX Internet page are not. Those courses are owned by the universities that produced those courses and they are not required to share them. Similarly, any organization can use its own copy of the Open EdX software to build its own course(s), and it would not be required to share the contents of that course(s). [69]

Open EdX platform was chosen for the experiment in Metropolia in the summer of year 2013 because it was free open source. It was not a whole organization-level official selection for Metropolia and that time the students of Media Technology degree program started an internal selftrial. They started to run to research, develop and work with EdX-system platform in the servers of Metropolia in order to make it suitable for the needs of Metropolia. In January year 2014, all documentation related to EdX platform was realized. [70]

Professor Hannu Markkunen is/was the project leader. Matti Peltoniemi, project engineer was/is responsible for installing and improving the EdX-system for Metropolia. The

aim of this group was/is to develop and add new features or courses (for example mathematics courses) to the EdX-system at Metropolia. [70]. At this moment the platform is in the testing phase and there are some courses in various areas running in the platform. [70] [71]. Still this platform was used to launch the new course of mathematics through Programming.

6.2 ICT Mathematical Applications course (TX00AA24-3002)

Sakari Lukkarinen is a teacher of mathematics and physics at Metropolia and he was interested in e-learning, MOOCs and the EdX as well. He was researching on various e-learning, MOOCs courses and MOOCs platforms.

Since year 2012, his aim of him was making an empowering e-learning environment for Metropolia. When the EdX system was made public, he created an experimental course for the students of Metropolia. This course was called ICT Mathematical Applications.

6.2.1 Course Description

ICT Mathematical Applications course (TX00AA24-3002) was held at Metropolia in spring, year 2013. ICT Mathematical Applications course included a classroom teaching and virtual teaching. Classroom teaching was held in Metropolia, in Espoo. Virtual teaching was in the EdX-test environment. The lecturer of ICT Mathematical Applications course was Sakari Lukkarinen who also decided for the content of ICT Mathematical Applications course and the instructors of ICT Mathematical Applications course were Sakari Lukkarinen and his team. The team of Sakari Lukkarinen consisted of Ali Ramz (me) as a Master thesis worker and Umesh Satyal as a project worker. The purpose of this team was to utilize the EdX system and develop the ICT Mathematical Applications course for Metropolia. This team defined, designed, edited and modified the content and deployed the course.

The purpose of ICT Mathematical Applications course was learning statistics through programming. The course therefore was designed as a hybrid course. Basically ICT Mathematical Applications course was an introduction to basic statistical concepts and Python language skills which are necessary for analysing data.

The component which used for building, editing and modifying the ICT Mathematical Applications course was Studio, online editor. The tool which used for programming is Pandas (Python data analysis library which included in Anaconda that is scientific Python distribution) language. The content which used for of ICT Mathematical Applications course was openIntro statistic which is an open source book in Statistics.

This course included examples by programming in Pandas (Python data analysis library which included in Anaconda that is scientific Python distribution) language in order to help making the connection between implementation and concepts. This course also used Pandas programming to implement and test basic data analyses. This course also introduced the basics of using Panda language scripts to perform reproducible research. On completion of the course the student has the basic knowledge of statistics, e.g. he/she can find answers to the questions such as how best can we collect data, how should it be analysed and what can we infer from the analysis.

6.2.2 Course Target and Goals

ICT Mathematical Applications course was a mandatory course for bachelors of engineering Information technology at Metropolia. The ICT Mathematical Applications course was aimed for any students of Information technology of Metropolia UAS, in any level of knowledge in Mathematics or programming. Therefore, any student of Information technology of Metropolia was eligible for the course.

The goals of the ICT Mathematical Applications course were learning statistics concepts by implementing these concepts and testing basic data analyses by Pandas programming language. This course also introduced the basics of using Panda language scripts to perform reproducible research. On completion of ICT Mathematical Applications the students would have the basic knowledge of the statistics, e.g. they can find answers to the questions such as how the data can be collected, how the data should be analysed and what could inferred from the analysis.

The evaluation criteria for the performance of the students of ICT Mathematical Application course were as follows:

1. Fail (0) if 50 % if tasks and assignments would be completed
2. Satisfactory (1-2) if 50 % if tasks and assignments would be completed

3. Good (3-4) if 70 % if tasks and assignments would be completed
4. Excellent (5) if 90 % if tasks and assignments would be completed

The evaluation methods of ICT Mathematical Application course were such as continuous assessment, self-evaluation, cross-evaluation and final exam. The teaching methods of ICT Mathematical Application course were such as activating lectures, exercises, home assignments and team work.

6.3 Definition and Design Content

ICT Mathematical Applications course included 7 modules 7 weeks long excluding overview of the EdX system and ICT Mathematical Applications course. The structure of each module of the ICT Mathematical Applications course contained introduction, development and conclusion by doing exercises. In the end of the ICT Mathematical Applications course there was the final exam. Every week on Friday from 5 p.m. until 8:30 p.m., one module was taught through classroom teaching. Every week a class was built in several bytes sized components including three to seven minutes video snippets, course slides, complementary videos, individual exercises, labs and quiz. Each component was modular and independent.

The concept design of the ICT Mathematical Applications course was organized as followings: About this course page which contained prerequisites, course introduction, descriptive image, instructor and staff biographies and titles, FAQ and photographs. Course info page which contained welcome announcement, collaboration and discussion forum guidelines, specific guidelines, syllabus, course schedule and course updates. Learning sequence page which contained online textbooks in PDF form, slides, lecture notes, learning exercise, video snippets, labs, quiz and wiki. Discussion forum page which contained discussion among the instructors and the student of ICT Mathematical Applications course was in the Tuubi environment of Metropolia UAS.

6.4 Course Plan

The distribution of content of ICT Mathematical Applications course was systemized as followings The contents of week one were introduction to python data analysis library-pandas, first lab exercise and video lectures. The contents of week two were introduc-

tion to data and second lab exercise. The contents of week three were probability, third lab exercise, video lectures. The contents of week four were normal distribution binomial distribution, slides, fourth lab exercise and video lectures. The contents of week five were foundation for inference, fifth lab exercise, video lectures. The contents of week six were confidence level, sixth lab exercise and video lectures. The contents of week seven were inference for numerical data, seventh lab exercise and video lectures. In week eight the final exam was held. It was open exam.

The students could work together as a team and discuss with each other in classroom freely but quietly. The final exam took three hours. In the end of exam Sakari Lukkarinen gave additional time and he announced that the students can restore the final solutions next day as well. He also decided that the deadline for returning the final exam would be the following day (typically Saturday evenings).

6.5 Challenges

Creating the ICT Mathematical Applications course was a massive attempt and presented many challenges for the instructors of the ICT Mathematical Applications and for the students as well. Matti Peltoniemi, the administrator of the EdX course for Metropolia was developing the EdX at the same time while the ICT Mathematical Applications course was being built and some parts of the EdX system such as Discussion forum were not functional.

The EdX system was unfamiliar to the students of Metropolia, and the instructors of the Mathematical Applications course were researching the EdX system for the first time. The concept of a hybrid course was new for the students of Metropolia. The content of the ICT Mathematical Applications course was not ready in advance. Sometimes the materials, slides, quizzes or labs of some modules were not ready or inadequate. Sometimes the qualities of video clips were low.

6.6 Benchmarks Courses in Coursera and EdX

Computing for Data Analysis was a course made by Johns Hopkins in Coursera. This course was about learning the basic computing skills which were necessary for effective data analysis. In this course the students learnt to program in R language. Using R language helped the students to read data, write functions, make informative graphs,

and apply modern statistical methods. The students learnt not only how to install and configure necessary software for a statistical programming environment but also learnt concepts as they are implemented in a high-level statistical language and discuss generic programming language. The course explained practical problems in statistical computing which included programming in R language, reading data into R language, creating informative data graphics language, accessing R packages language, creating R language packages with documentation, writing R language functions, debugging, and organizing and commenting R language code. [72] [73] [74]

"Statistics: Making Sense of Data" was a course made by University of Toronto in Coursera. This course was an introduction to the principles and ideas of the collection, display, and analysis of data to guide the students in making valid and appropriate conclusions about the world. This course provided an intuitive introduction to applied statistical reasoning, introducing basic statistical skills and acquainting the students with the full process of inquiry and evaluation which used in investigations in a very wide range of fields. This course provided methods of data collection, constructing effective numerical and graphical displays to understand the data; how to describe and estimate the error in estimates of some important quantities, and the ideas in how statistical tests could be used to detached significant differences from those that were only a reflection of the natural variability in data. In this course R language was used. [72] [73] [74]

Statistics and R for the Life Sciences was a course made by Harvard school in EdX. It was an introduction to fundamental statistical concepts and R language skills which were necessary for analysing data in the various sciences. The students learnt the fundamental of statistical inference in order to comprehend and computed the probability of obtaining the observed sample results and confidence intervals. This course included examples by programming in R language in order to help making the connection between implementation and concepts. This course used R programming to implement and test basic data analyses. This course used visualization techniques to study new data sets and determine the most appropriate approach. This course also introduced the basics of using R language scripts to perform reproducible research. [85] [86]

Introduction to Big Data with Apache Spark was a course made by Berkeley, University of California in EdX. In this course the students learnt how to apply data science techniques using parallel programming in Apache Spark to explore small and big data. Or-

ganizations use their data in order to support their decision and to build data-intensive services and products, such as prediction, recommendation and diagnostic systems. The collection of these skills which are required by organizations in order to support these functions has been grouped under the term which called Data Science. This course Endeavoured to articulate the expected output of Data Scientists and then taught the students how to use PySpark (part of Apache Spark) and to carry against these expectations. Assignments of this course included Textual Entity Recognition, Log Mining, Collaborative Filtering exercises that taught students how to manipulate data sets by using parallel processing with PySpark. This course required a programming background and experience with Python. [75]

6.7 Benchmarks in EdX System at Metropolia

The first pilot course in the EdX system of Metropolia, University of Applied Sciences was MP0002 Digital Media Algorithms and it was held in October 2013. The teacher of the course was Professor Hannu Markkanen. This course consisted of independent work in the EdX, according to the instructions of Professor Hannu Markkanen and weekly (almost 3-hour) group exercises in computer labs. The aim of the course was to study the necessary information of the exercises in advance. The study material consisted of short videos, book online and interactive programming training environment.

The course objectives for the students of the course were such as knowing the algorithms used in software development principles and knowing that they are able to assess the time and space requirements, knowing the data sorting and searching criteria and knowing how to use and implement dynamic data structures (lists, stacks, queues, trees, networks) their processing algorithms necessary. Course contents were such as introduction to algorithms and data structures, python basics of the course to the needs, basic data structures and their treatment, recursion, evaluation of Algorithms, linear data structures, search and sorting, devolution, woodwork and networks (graphs). In this course, the students should use a programming language is Python. This pilot course was mostly for the students who spoke the Finnish language. The text and instruction of the course were in Finnish but educational resources and video clips were in the English.

7 Components and Tools Used in Development of ICT Mathematical Applications Course

The component for building the ICT Mathematical Application course was Studio, online editor. The Studio, online was explained before. So there is no need to explain it again here. The tools which used in ICT Mathematical Application course were Pandas programming language, continuum analytics' anaconda - scientific python distribution and wakari. [76]. In this chapter Pandas, openIntro statistics and continuum analytics' anaconda are explained briefly.

7.1 Pandas

In year 2008 Wes Mckinney proceeds to develop Pandas in the AQR Capital Management firm. In his opinion Pandas was a pliable tool to execute quantitative analysis on economic data. He succeeded to make Pandas as open source library. In 2012 Chang She continued developing Pandas and in the same year Pandas became a popular in the python programming language community. Python was a particular tool for data preparation, but it was not a particular tool for data analysis and modelling. But Padas was a great tool for data analysis and modelling. Pandas was merged to the other libraries of python and it made its statistical modelling environment of Python programming language. Pandas implements just the significant modelling functionality for the panel and linear regression. [77] [78] [79]

Pandas was chosen as the programming language for the statistics in ICT Mathematical Application course by Sakari Lukkarinen. Pandas is not difficult even for the students who have no experience about programming and the students could learn it in a short time. Pandas is an effective programming language for data manipulation.

7.2 OpenIntro Statistics

OpenIntro statistics is a part of OpenIntro which is a free online educational environment in different subjects such as algebra, calculus, statistics, medicine and physics. The main purpose of OpenIntro is to create free, clear and lower hurdle pedagogical product for education. Because OpenIntro resources were chosen by instructors over the other expensive options, during year 2010-2014 could success to reduce costs of student by $600,000. [80]

OpenIntro statistics a free online studying environment in Statistics which is come from OpenIntro Statistics textbook. OpenIntro Statistics textbook is an open-source textbook for introductory statistics. The textbook is obtainable not only as a free PDF on the Internet but also as a royalty-free soft-cover. Statistic page of OpenIntro consists of many parts such as textbook, labs, videos, teachers, forums and extra part. [80]

Pandas was chosen as the programming language for the statistics in the ICT Mathematical Application course by Sakari Lukkarinen. OpenIntro Statistics content was used in the statistics courses in Coursera and the content and the exercises of the OpenIntro were suitable for ICT Mathematical Application course.

7.3 Continuum Analytics' Anaconda - Scientific Python Distribution and Wakari

Wakari is one of the products of Anaconda. Anaconda is a free enterprise ready for Python programming language distribution for predictive analytics, scientific computing and large-scale data processing. Anaconda is absolutely free for the normal users, commercial use and redistribution. Anaconda has more than three hundred thirty of the libraries of Python in various areas such as data analysis, mathematics and engineering. Anaconda is excellent for supporting the virtual environments. Anaconda has the tools which are connected and integrated to Excel.

Wakari is an environment for modern data analytics. Wakari collaborates with the IPython notebooks.The users of fully-configured Wakari can easily analyse data in a short time. The features of Wakari are such as Wakari is in the cloud, Wakari can be downloaded easily and securely from its address to any server(s), Wakari prepares accessing to the computed data and resources, Wakari visualizes data, Wakari reproduces the process and Wakari shares the findings and results in a simple manner. [89]

Continuum Analytics' Anaconda - Scientific Python distribution and Wakari was chosen as the lab environment for the statistics in ICT Mathematical Application course by Sakari Lukkarinen. Anaconda is free and easy to sign up. Anaconda contains IPython notebooks and packages which can be shared. Anaconda is a suitable environment for manipulation data related to statistics.

8 Result of Analysis of ICT Mathematical Applications Course

Implementing of ICT Mathematical Applications course was carried out in order to e.g. make a template for the ICT Mathematical Applications course by studio online editor, put the content of the course in the template week by week, and test the online ICT Mathematical Applications course before classroom teaching.

8.1 Implemented Pages

In this project, an ”About this course” page was implemented by the team members. In ”About this course”, the parts such as “the course name”, "Prerequisite", "Course staff", "Descriptive picture", "Course number", "Class start", "Class end" and "Estimated effort" were implemented successfully. But "Staff biographies", "Frequently asked questions" (FAQ) and "About this course video" were not implemented. Also implementing the parts such as “sitemap” or “donate” was not necessary.

In this project, a ”Courseware” page was implemented by the team members. The left side of the Courseware of the course contained a course navigation bar which started from top to down. ICT Mathematical Applications course started with an overview of EdX system which was an introduction to the courses of EdX generally. Every week one the section of the ICT Mathematical Applications course was built and delivered to students. Every section contained subsections and every subsection contained units. Every unit contained components which were videos, text, links, laboratory instructions, exercises, assignments, html, discussion and problems.

The project team produced video shooting and made materials of the course every week. First, most of time of the project time and efforts was used for researching EdX system. Second, designing the course required a long time. The course material was of high quality. The video shooting was conducted during the lectures and the video clips were placed directly in the courseware simultaneously. Occasionally the qualities of the video clips were not of high quality. Sometimes the video clips were dark or the sound of the lecturer was not clear and making subtitle for the video clips was not successful in Youtube. According to the opinion of the author of the course material should be made and tested three to two months before the course starts.
”Digital text” page was an environment where the learning materials of the ICT Mathematical Applications course were downloaded chapter by chapter by Sakari Luk-

karinen. The learning materials of ICT Mathematical Applications course was the second edition of OpenIntro Statistics book which was an open source. OpenIntro Statistics book was written by Diez, D & Barr, C. & Cetinkaya-Rundel, M. in year 2012. This book is available in PDF form in the internet or can be purchased from Amazon internet book shop. This book is also available in the Metropolia library. The book is under creative common license. The ”Digital text” or “OpenIntro Statistics, 2nd edition” page was completely implemented in EdX platform for Metropolia when ICT Mathematical Applications course started to be implemented and in this project this practical feature helped the students and the instructors of ICT Mathematical Applications course supremely. The students of the ICT Mathematical Applications course could print this book if they so wished as well.

”Wiki” page generates a spot for the students and the instructors of the course to share their ideas. In wiki area the students and the instructors can collaborate, edit the page to spread the resources and co-create their understanding. ” Wiki” page was completely implemented in EdX platform for Metropolia when ICT Mathematical Applications course started to be implemented. Sakari Lukkarinen started to share the idea with the students of ICT Mathematical Applications course by writing articles such as “normal distribution generator” and “simple normal distribution”. But the students of the ICT Mathematical Applications course were not active in “wiki” page. In the author’s opinion ”Wiki” page is useful feature which makes the students and the instructors of the course to communicate and first the instructors should start to write articles and start communicate with the students of the course.

In the lab part, the python codes were written in IPython notebooks and the Python codes were embedded with html codes. Codes were interpreted in pleasant statistics and visuals tools such as vivid graphs and curves. The Ipython notebook files were allocated with the students of the ICT Mathematical Applications course where they could complete the labs of the ICT Mathematical Applications course and submit these to the instructor(s) of the ICT Mathematical Applications course. Each lab included exact and complete instructions the students of the ICT Mathematical Applications course which were facile to follow. Each lab contained the check box problems, the multiple choice questions, the open response assessments and custom python evaluated problems which appeared in the end of the labs.
In the authors’ opinion, it was better to implement the check box problems and the multiple choice questions in the middle of the video clips of the lecture or the study material

to test the students and give them short pause to review in their mind what the lecturer taught or what they learnt from the study material. These check box problems and multiple choice questions should be definitely tricky and make the students to think precisely to solve these questions and problems and as long as the student cannot give the correct answer to these questions and problems, they cannot continue watching video clips or studying the study material.

"Open ended panel" page opens "Open ended console" page. Open ended console is available optional page for every course in EdX platform. Open ended console indicates "staff grading" page, "flagged submissions" page and "problems you have submitted" page. ” Open ended panel” page was entirely implemented in EdX platform for Metropolia when ICT Mathematical Applications course started to be implemented.

"Progress" page is one of the best features of EdX platform. "Progress" page generates a visual manifestation of the progress of the students of the course through the grading process. In the “Progress” page the students of the ICT Mathematical Applications course monitor their own progress in the tests, the assignments, the labs, the final exam and the total score through the ICT Mathematical Applications course. The students of the ICT Mathematical Applications course could watch how many exercises or labs they have completed, their score on every exercise or labs and how many exercises or labs remained behind. The x-axis of the bar graph of the "Progress" page of the ICT Mathematical Applications course monitored all the homework of the ICT Mathematical Applications course and the y-axis of the bar graph of the "Progress" page of the course monitored the progress of the students of the ICT Mathematical Applications course in percentage.

The “Progress” page was completely implemented in EdX platform for Metropolia when the ICT Mathematical Applications course started to be implemented and in this project this valuable feature helped the students and the instructors of the ICT Mathematical Applications course extremely.

“Instructor” page contains “course basic information”, “data download” which includes the profile information of the enrolled students of the course, “analystic” which includes gender and grade distribution of the students of the course. “Instructor” page contains also “admin”, “forum admin” and “manage groups”. “Instructor” page was entirely im-

plemented in EdX platform for Metropolia when the ICT Mathematical Applications course started to be implemented.

When the ICT Mathematical Applications course was taught to the students of Metropolia, the lab environment was Wakari and it Wakari is neihter implemented nor integrated in EdX system. In the author's opinion the "lab environment" page should be entirely implemented in the EdX platform the next time when the ICT Mathematical Applications course will be started for the students of Metropolia.

8.2 Partly Implemented Pages

The"Course info" page included any important news and updates. Sakari Lukkarinen posted news and updates of the ICT Mathematical Applications course for the student of the ICT what the course about, what are the course materials were, what the important links were, etc. The "Course info" page contained a handouts sidebar as well. In theEdX platform handouts sidebar includes important links to auxiliary information for the course. The handsouts sidebar was not functional when the ICT Mathematical Applications course was running in theEdX platform of Metropolia.

8.3 Pages Not Implemented

The "Discussion" page was not implemented when the ICT Mathematical Applications course was running and Sakari Lukkarinen suggested that the students of the ICT Mathematical Applications course started to use the Discussion part of the Tuubi environment of Metropolia, where the instructors and the students of ICT Mathematical Application course could discuss the ICT Mathematical Application Course and swap ideas. In the early 2015, the "Discussion" page was completely implemented in the EdX platform for Metropolia.

The "Calendar" page contains the number of every week of the course, the dates of releasing of the course, the topic of the course, the reading where with the chapter numbers and the section numbers of the course, the lecture number of the course, the sequence of the course, the problem of the course, the set problem of the course and the set due date of the course. The "Calendar" page was not implemented in the EdX platform for Metropolia, when the ICT Mathematical Applications course started to be

implemented. So, the students of the Mathematical Applications Course could not use this feature. This feature is, however needed for the students of Metropolia, because the “Calendar” page works like a reminder telling the students the structure of the course and the dates of the chapter numbers and the section numbers of the course.

9 Feedback after Course Implementation

In the end of the course, the participants of the course and Sakari Lukkarinen were asked for constructive feedback. The aim was to collect feedback from the students and Sakari Lukkarinen and take it into account when implementing the course for the next time, for learning mathematics, and using an EdX course and EdX as a new tool.

9.1 Student Feedback

At the end of the course semester, a feedback questionnaire was sent through email to the students who participated in the course. Seventeen students participated in the inquiry. The interviewed students' age was between 21 and 46 years and all were male. Part of the interviewed students had experience in programming where as part of the interviewed students did not have experience in programming. The interviewed students were from different countries and with different cultures. The education levels of the students interviewed were between first grade of study year students and fourth grade of study year students. No one of interviewed students had experience of EdX system, platform and courses before.

The feedbacks of the students were received 23.10.2014-29.12.2014. The questionnaire contented eleven questions. The first two questions were structured questions and other nine questions were open questions. Below is the questions of the questionnaire.

	Questions
	1. I learnt statistics through programming (Python). 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree 2. I want to learn more mathematics. 1 = strongly disagree 2 = disagree 3 = neutral

	4 = agree 5 = strongly agree 3. The continuous evaluation is better than final examination. (Please explain why). 4. How would you improve this course? 5. What has been positive or impressive in the course? 6. What has been challenging or disturbing in the course? 7. How well were your goals and expectations for the course met? (Please explain why). 8. What is your general impression of the EdX tool? What is good about it? 9. What have been the most helpful features of the tool? 10. What have been the most disturbing features of the tool? 11. Lastly you can add your free feedback and comments here

Q-1. Six students answered to the first question. Five students were “agree” and one student was “neutral”.

Q-2. Six students answered to the second question. Four students were “agree”. One student was “neutral”. One student was “strongly agree”.

Q-3.Ten students answered to the third question. All the student agreed that continuous evaluation is better than final examination. Because continuous evaluation gives to the students accurate and strong information about the course.

Q-4. Ten students answered to the fourth question. Nine students were agreed that the course should be more organized and all material of the course should be prepared in advance. One student answered that the course was totally great.

Q-5. Ten students answered to the fifth question. Their answers were such as hybrid course of Statistics and Programming was impressive. Online learning materials were constructive and impressive. The course was practical. It was good to work in group and collaborate.

Q-6. Ten students answered to the sixth question. Their answers were such as exam was difficult. We needed longer break during the class. Learning code is challengeable. Some exercises were badly phrased. Discussion page was dysfunctional. EdX was new experience.

Q-7. Ten students answered to the seventh question. Their answers were such as Python and Pandas are brilliant and effective tools. We understood statistics through programming and learnt new course with new method.

Q-8. Nine students answered to the eighth question. Their answers were such as EdX is new, brilliant, effective, empowering and inspiring tool with many brilliant features.

Q-9. Seven students answered to the ninth question. Their answers were such as the content is sufficient, accurate and short. It is easy to access. EdX platform is easy to use.

Q-10. Seven students answered to the tenth question. Their answers were such as many parts were dyfunctional or not implemented during the course semester. These part were such as discussion page, FAQ Jobs, handsout

Q-11. Seven students answered to the eleventh question. Their answers were such as we are happy to be familiar with EdX. It is good to take this tool and develop it for needs of Metropolia. Hybrid course and online EdX system are very interesting. EdX system, platform and courses are suitable for massive users. The content of the course should be ready and tested before starting the course.

The answers of the interviewed participants of the ICT course prove that the learning statistics through Python was influential, great hybrid course. It was easy to learn statistics through mathematics. The content of the ICT course was sufficient, short and accurate. It is very important that the content of the course is tested and ready before starting the course. EdX is inspiring and empowering tool which is effective. EdX platform is straightforward and simple to use. The students of Metropolia UAS are prepared to use EdX constantly.

9.2 Feedback from Sakari Lukkarinen

I interviewed and asked the same questions I asked from the students of the ICT Mathematical Applications course from Sakari Lukkarinen about the course. The interview was open and it was conducted in 21.11.2014 in the office of the Senior lecturer, Sakari Lukkarinen located in Metropolia, in Espoo, Finland. Sakari Lukkarinen answered to the question three to question eleven.

Q-3. The answer to the question number three was “Yes, both the teacher and student get continuously feedback what could be done differently”.

Q-4. The answer to the question number four was “If the Python is not used in other courses, then the original language used in the material, R, might work better for this course. If this course will be run several times, then EdX could work better as implementation platform. Then this course could also be provided for wider audience. ”.

Q-5. The answer to the question number five was “The students were really eager to study the topics and do the laboratory exercises. That really impressed me. Also the class exam impressed me positively. I could see how they wanted to show their skills and knowledge”.

Q-6. The answer to the question number six was “I assumed that there would be more interactive and collaborative tools in EdX. But it seemed that it is tuned specially for MOOCs where the main aspect is the automation of evaluation. As I taught this only once, the preparation was difficult.”.

Q-7. The answer to the question number seven was “I don’t remember the goals and expectations anymore. But looking from retro perspective I was rather happy and satisfied how the course went and the results”.

Q-8. The answer to the question number eight was “EdX is excellent for MOOCs. The automated systems take one painful (laborious assessment) part away from the teaching”.

Q-9. The answer to the question number nine was “I would say that the layout and how the course is organized. Comparing to Moodle, the format and use of the tool is much simpler and intuitive for the students and the teachers”.

Q-10. The answer to the question number ten was “The fully automated assessment. It requires that your course is well established and most of the details designed, planned and tested.”.

Q-11. The answer to the question number eleven was “EdX has advantages and disadvantages. By knowing them we can use the tool with more efficiency. For more experimental courses other tools might work better”.

The answers of Sakari Lukkarinen indicate that the positive reaction of the students to the ICT course impressed him very much. EdX would bring out the hidden positive features in the students. The best feedback can be received from students of the ICT if this course will be run several times. EdX has more interactive and collaborative tools. EdX is excellent for MOOCs. Comparing to Moodle, EdX is more organized and the format and use of the EdX is much simpler and intuitive for the students and the teachers. EdX has advantages and disadvantages. By knowing them we can use EdX with more efficiency.

9.3 Other Instructors and Researchers

In 5.10.2015, I did a questionnaire about the EdX system through email for two instructors, one researcher of the EdX system of Metropolia UAS, and one instructor of Helsinki University. The aim of this questionnaire was receiving feedbacks from these instructors and researchers about the EdX course and the EdX as new tool. The questionnaire had eight open questions. Bellow questions are the questions of this questionnaire.

	Questions
	1. What are the best features in EdX? 2. How would you improve EdX? 3. What are challenging or disturbing in EdX?

	4. What is positive in EdX? 5. How well EdX met your expectations? 6. What is your general impression of EdX? Good or bad? 7. What are the most helpful features and disturbing features in the tool? 8. Do you have any comments to add?

One instructor of Metropolia and one instructor of Helsinki University participated in the inquiry. I received the feedbacks of the instructor of Metropolia, in 6.10.2015 and feedbacks of the instructor of Helsinki University in 15.10.2015. Because of privacy, the instructor of Metropolia is here by referred as H. M. and the instructor of Helsinki University as M. L.

9.3.1 Metropolia Instructor

Instructor H. M. answered to questions one to seven and he did not add any comments about the EdX system. The answer to the question number one was “Reliability”. The answer to the question number two was “Support for groups and staff graded assignments”. The answer to the question number three was “Navigation within learning materials on subsection level (i.e. between units)”. The answer to the question number four was “Wide adoption and plausible development road map”.

The answer to the question number five was “Quite well”. The answer to the question number six was “Good for the usage scenario that it has been developed for”. The answer to the question number seven was “Easy and coherent GUI and course building process. Server installation and maintenance is quite laborious and requires special skills”. In addition instructor H. M. said that he does not use online courses at this moment.

9.3.2 Helsinki University Instructor

Instructor M. L. answered to all of the questions about the EdX system. The answer to the question number one was “CMS and LMS are effective in the EdX”. The answer of instructor M. L. to the question number two was “Courseware page is not well designed”.

The answer to the question number three was “When I first started to use the EdX, I found it very confusing. Because the EdX courses and studio, online editor are in different web addresses.” The answer to the question number four was “It is positive that the EdX is developed as open-source software by good universities”.

The answer to the question number five was “The course that I built by the EdX (KNORK Online Teacher Training Package) is not meant to be used as a real MOOC”. The answer to the question number six was “using of the EdX might be difficult for teachers/users who are less competent with technology”.

The answer to the question number seven was “I actually like the simple layout and structuring of the Courseware page. Because the EdX is meant for running MOOCs, it represents quite teacher-centered approach to pedagogy (e.g. I newer use ready-made task types such as multiple-choice questions in my training). The answer to the question number eight was “I have not used the EdX with students, only once I created one course material package with the EdX. Therefore I have quite limited experience of its possibilities.”

In addition, instructor M. L. said “ the EdX will be used in KNORK "Online Teacher Training Package" project very soon. KNORK project has not been completed yet. It is possible that the other partners of KNORK project such as Italy, Bulgaria and Sweden may copy from the servers of Metropolia and translate the materials of KNORK project into their language.”

10 Discussion

Academic and educational literature suggests that providing organized, interesting, short, succinct and strong online courses motivate and inspire the students. At this moment, the EdX system and platform is one of the best options to make online courses for the students any of teaching organization. The EdX system and platform is an open source which is reliable and flexible. The researchers and instructors of Universities of Applied Sciences are installing and modifying the EdX system and platform as test environment in the servers of Universities of Applied Sciences and making pilot online courses according to the urges of Universities of Applied Sciences for the students of Universities of Applied Sciences. At the time of writing this paper, Matti Pel-

toniemi, project engineer is developing more and administrating the EdX system and platform for based on needs of Metropolia.

The project team members for making the ICT Mathematical Applications course were three persons who did not have much experience about the EdX system and platform. There was needed for more team members for making the ICT Mathematical Applications course. The time for researching the EdX system and platform, searching proper content for the course, setting the content for ICT Mathematical Applications course and testing the course was short and the project team was forced to speed up.

The EdX system and platform was new both for the instructors and the students of the ICT Mathematical Applications course. The “Discussion” page was not functional and the instructors and the students of the ICT Mathematical Applications course were forced to use the discussion forum of the Tuubi environment of Metropolia University of Applied Sciences. The lab environment for programming for solving the assignments of the ICT Mathematical Applications course was not implemented in the EdX system. These problems required more patience from the instructors and the students of the course in question.

The ICT Mathematical Applications course as a pilot hybrid course was new for the students of Metropolia, and the reaction of the students was gratifying. The ICT Mathematical Applications course was innovated and raised new ideas about statistics and programming for the students of the course.

As for my part in the project, I was shooting videos from the lectures of the ICT Mathematical Applications course when Sakari Lukkarinen was lecturing in classroom. Occasionally the video clips were not made successfully. Occasionally the sounds of video clips were not clear or the video clips were dark and I could not use subtitles of Youtube for the video clips of lectures of the course.

The ICT Mathematical Applications course was taught only once, in spring year 2013, because the curriculum of Metropolia changes every second year. Seventeen students of the ICT Mathematical Applications course answered the feedback questionnaire about ICT Mathematical Applications course and gave their feedback. Also Sakari Lukkarinen, instructor of ICT Mathematical Applications course answered to the questionnaire and gave his feedback. A questionnaire about the EdX system and platform was

sent to fifteen researchers and instructors at various Universities and Universities of Applied Sciences working with the EdX system and just two of them answered to the questionnaire about using the EdX system and platform and thus gave their feedback, too.

Based on the result of this one pilot, I can share my opinion and observations which can be used when launching similar courses in the future. First, the courses of Metropolia University of Applied Sciences are meant for a small group of students with various education level. The structure of these courses should be modified by instructors according to the education level of the new students. The instructors might be forced to direct the study material of the courses based on the needs and level of understanding of the new students every year. So, the instructors cannot make any constant recipe for the study material of the courses of Metropolia. On other hand, the curriculum of Metropolia changes almost every year. All of these above-mentioned facts are against the policies of MOOCs, the EdX courses, the EdX system and the EdX platform. There are specific needs for building great the EdX courses and using the EdX system and the EdX platform successfully. The first one is that there should be the project team which just focuses on building the EdX courses. The second one is that there should be a specific curriculum for almost at least ten years. The third one is that there should be a ready, already estimated, tested and constant recipe for the study material of the EdX courses.

Therefore, I believe based on this first experience, that the EdX system and platform will be more popular in Universities around the globe in the future. I think by developing EdX system and platform and making interesting online courses, Universities of Applied Sciences in Finland will reduce costs and obtain the interest of the students who study in Universities of Applied Sciences. It is possible that Universities of Applied Sciences make business from such online courses and export online courses to other Universities around the globe.

11 Conclusion

Based on this first experience of launching the ICT Mathematical Applications course at Metropolia UAS, it can be argued that EdX system and platform is a reliable and flexible open source which is suitable for making online courses for the students of Universities of Applied Sciences comparing with the other online system and platforms. The EdX system and platform is designated for the highly designed and prepared massive online courses with great recipe for the study material which specifically evaluated and tested from start point of the courses to the end of the courses. These online courses should be designed for the massive crowd of the students. The Trajectory of these massive online courses should be ten years.

Developing a massive online course is highly time consuming. For developing a massive online course, the optimal project team should consist of several members, at least three members who do multitasking jobs. The massive online course should be implemented and tested three to two months before the course gets started. The content of the massive online course should be definitely short, succinct and strong and it should be inspiring, motivating and empowering.

In the future, a wide range of hybrid courses such as the ICT Mathematical Applications course may raise interest and attention among the students of Metropolia, since these courses generate new ideas and provide more orientations for students. This experience suggests that the process of deploying of EdX system and platform in the Universities of Applied Sciences is also slow. The most remarkable reasons for this problem are the lack of the budget and the work culture of the Metropolia, developing the courses such as ICT Mathematical Applications requires more teaching periods, more questionnaires and getting more feedback from the instructors and students of Universities of Applied Sciences.

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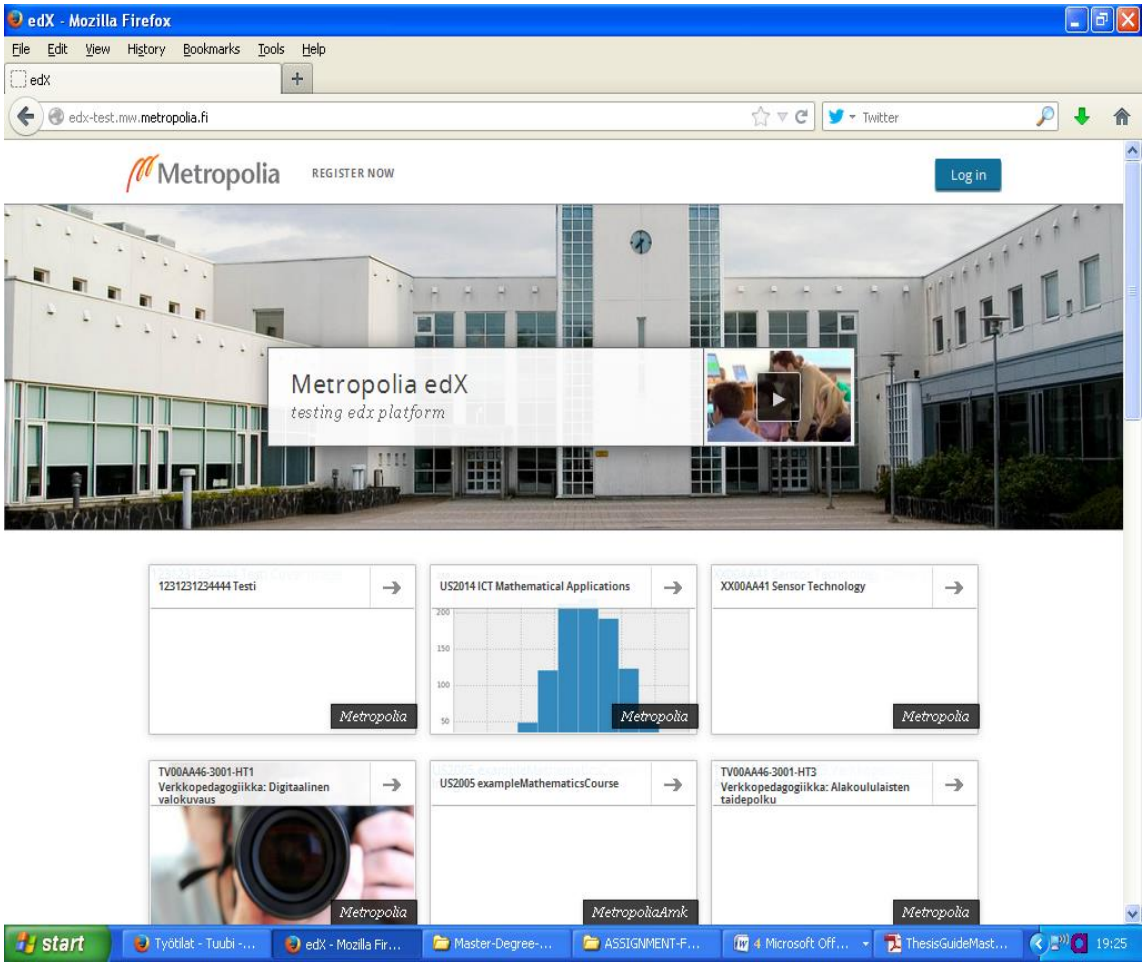
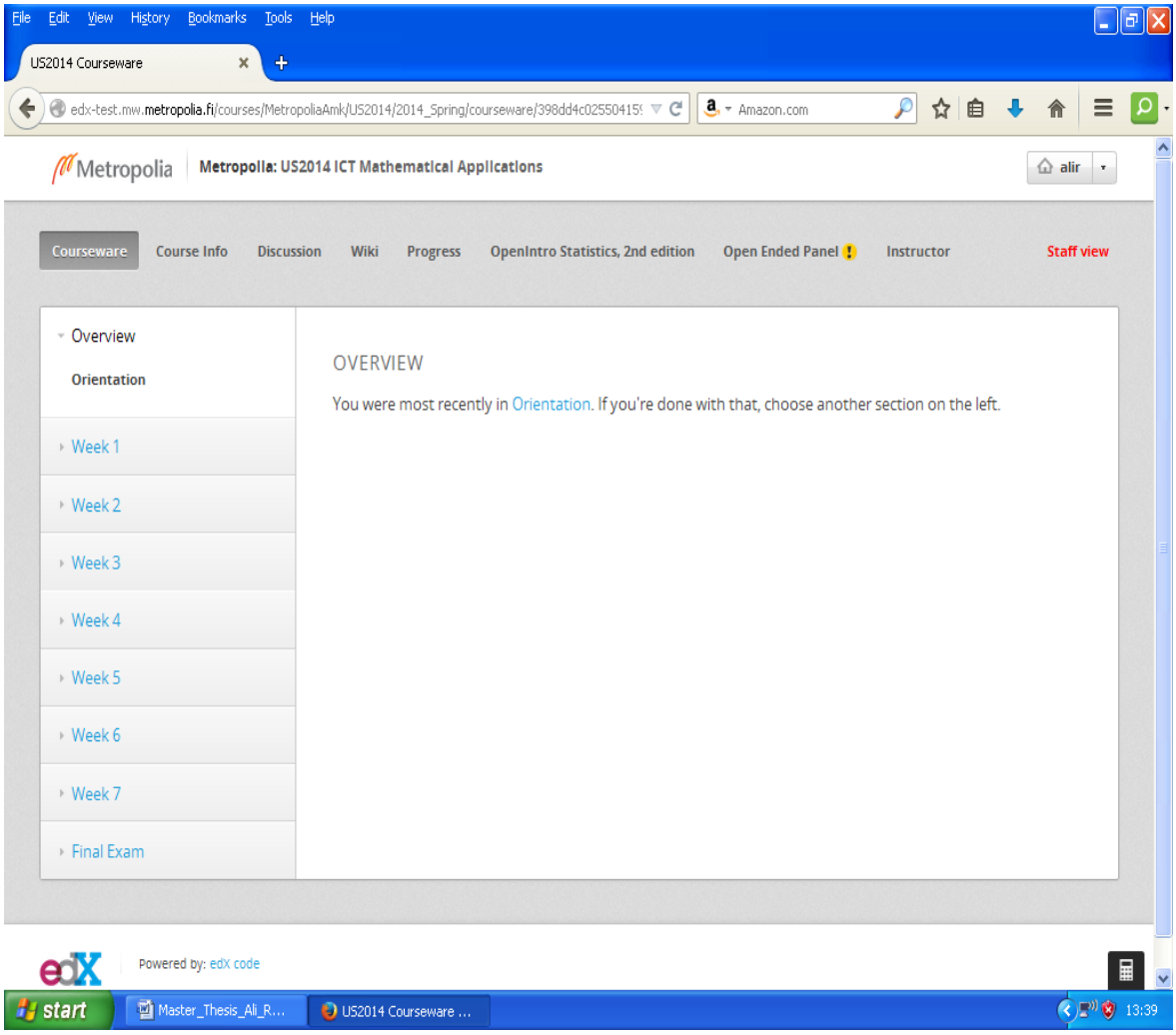
Appendix 1.

The web page of EdX at Metropolia



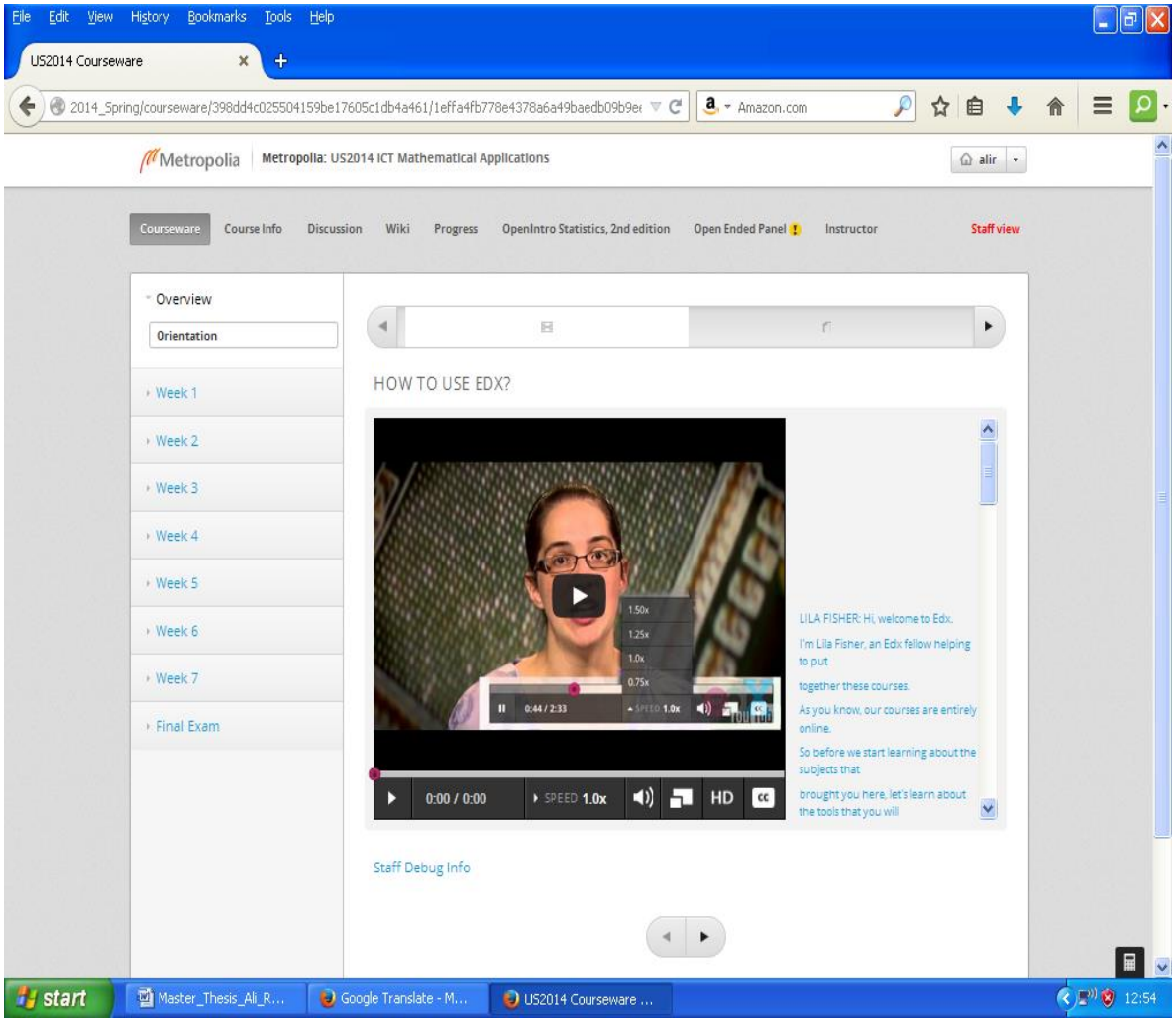
Appendix 2.

Courseware page of ICT Mathematical Application course



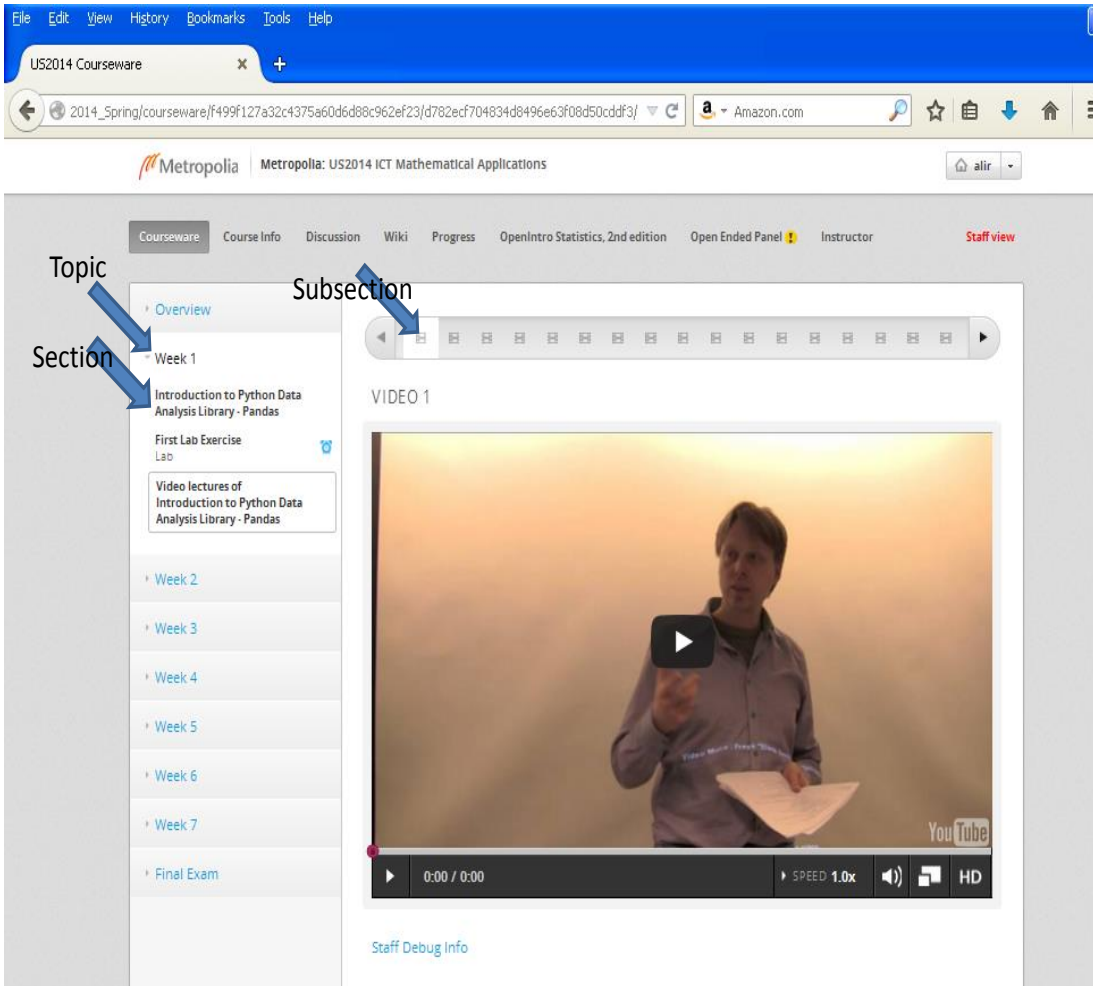
Appendix 3.

Overview and Orientation of ICT Mathematical Application course



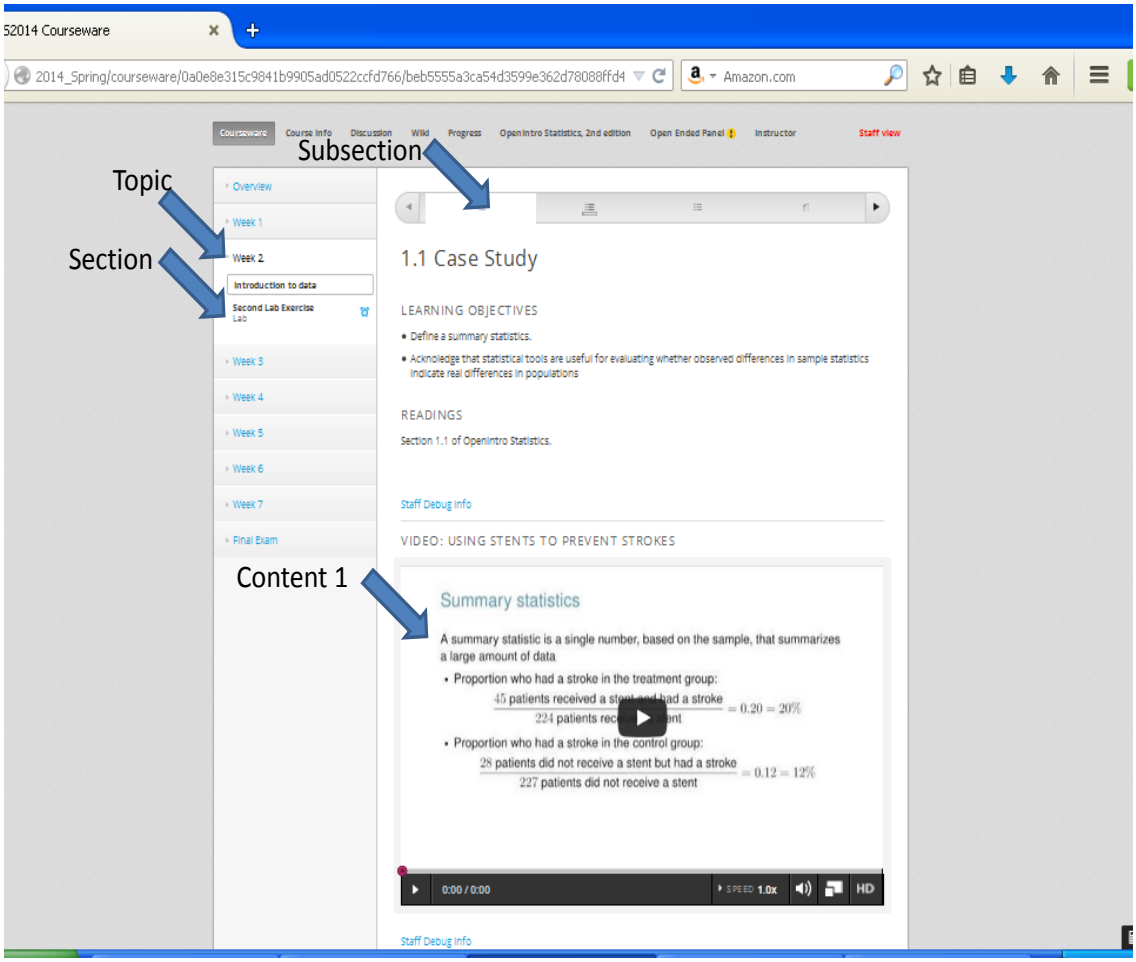
Appendix 4.

Topic, Section and Subsection of Week 1 of ICT Mathematical Application course



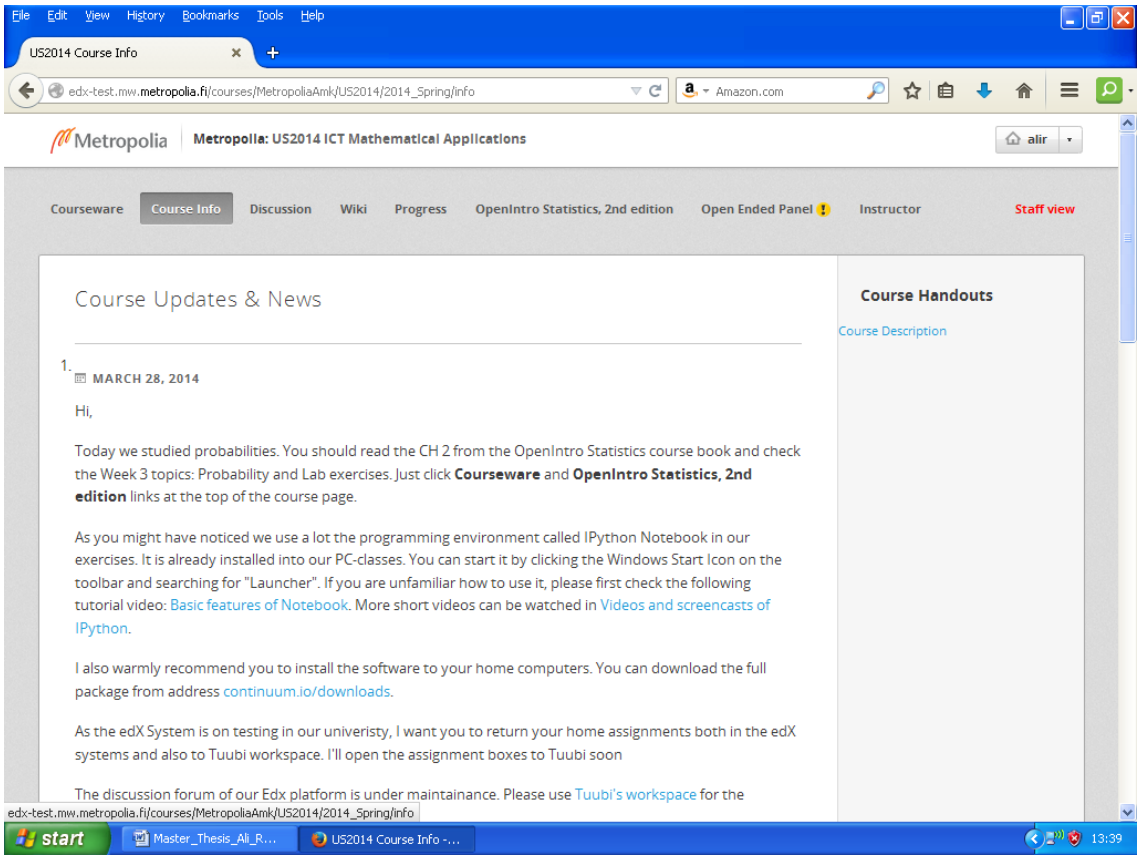
Appendix 5.

Topic, Section, Subsection and Content1 of Week 2 of ICT Mathematical Application course



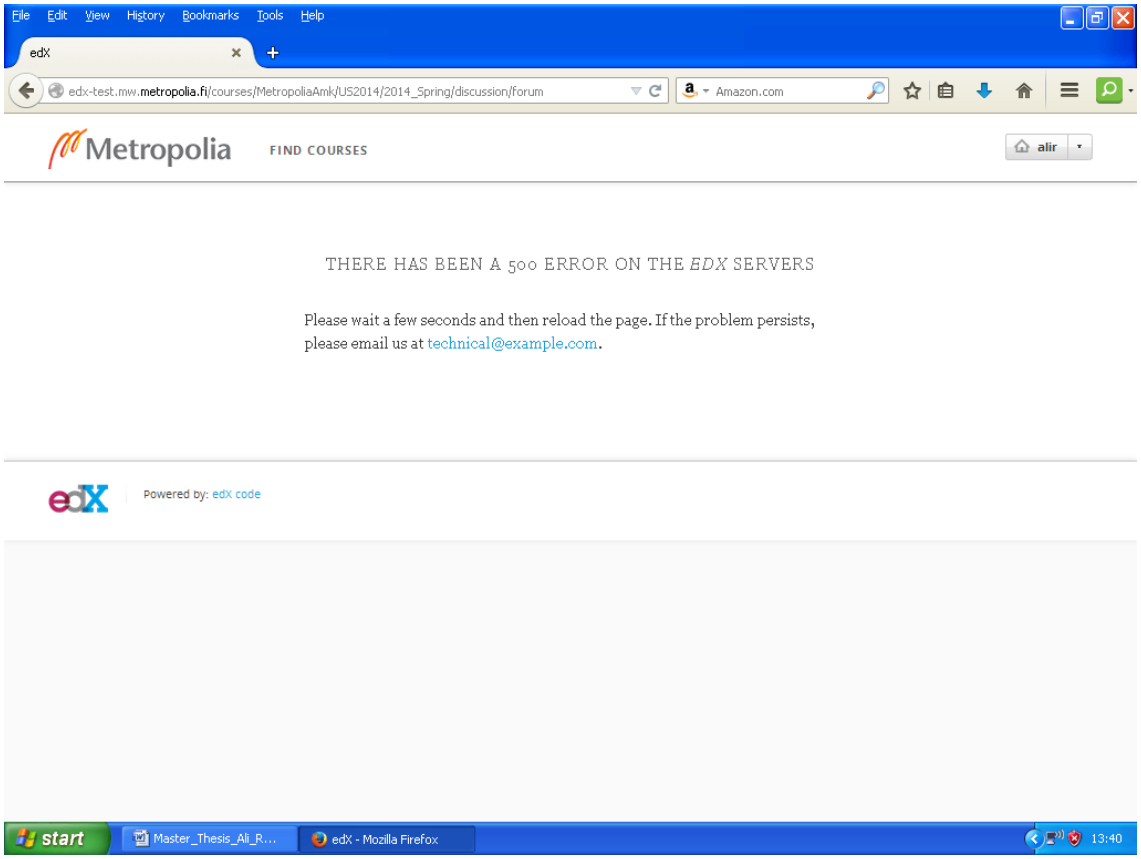
Appendix 3.

Course Info page of ICT Mathematical Application course



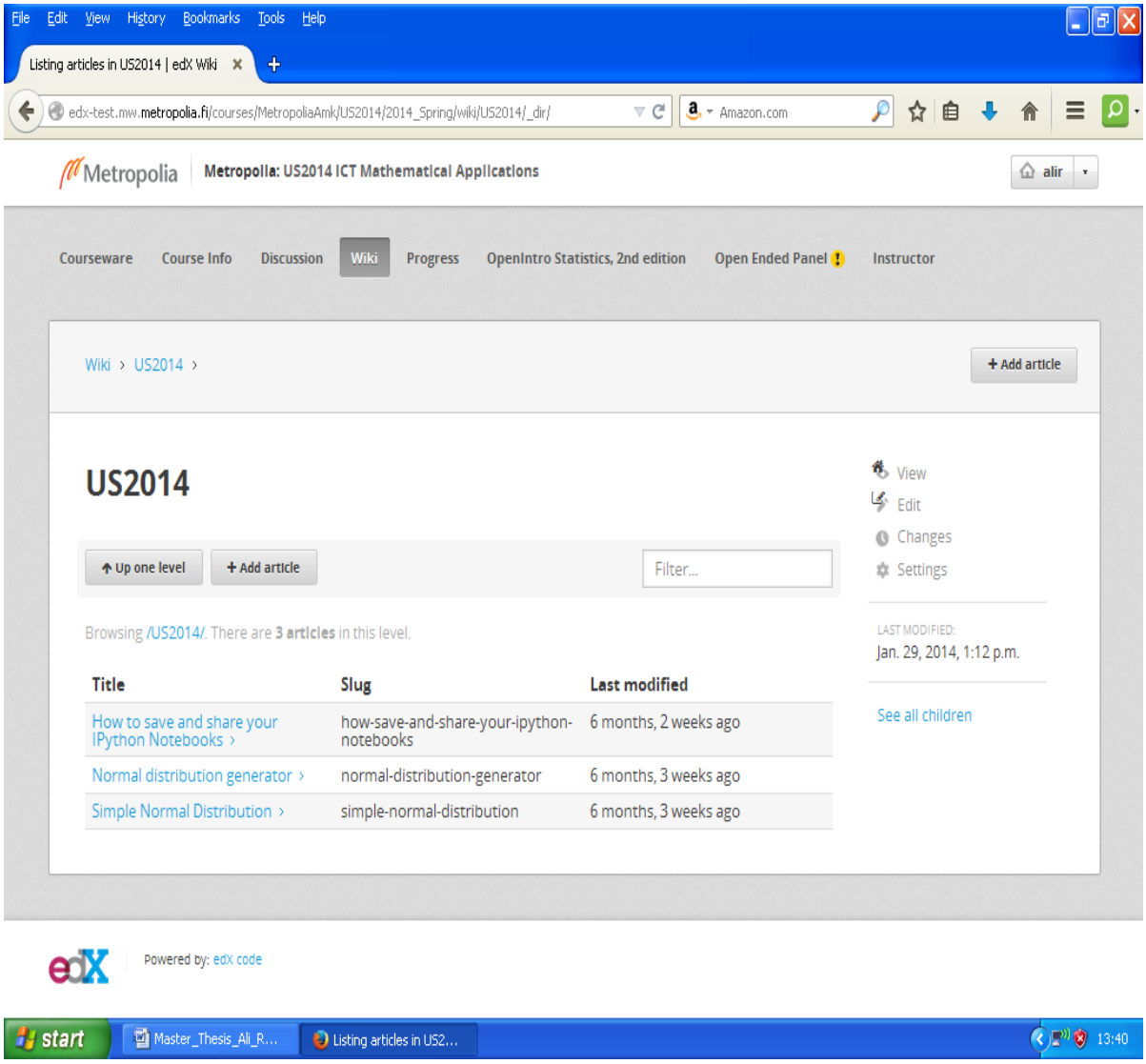
Appendix 4.

Discussion page (dysfunctional) of ICT Mathematical Application course



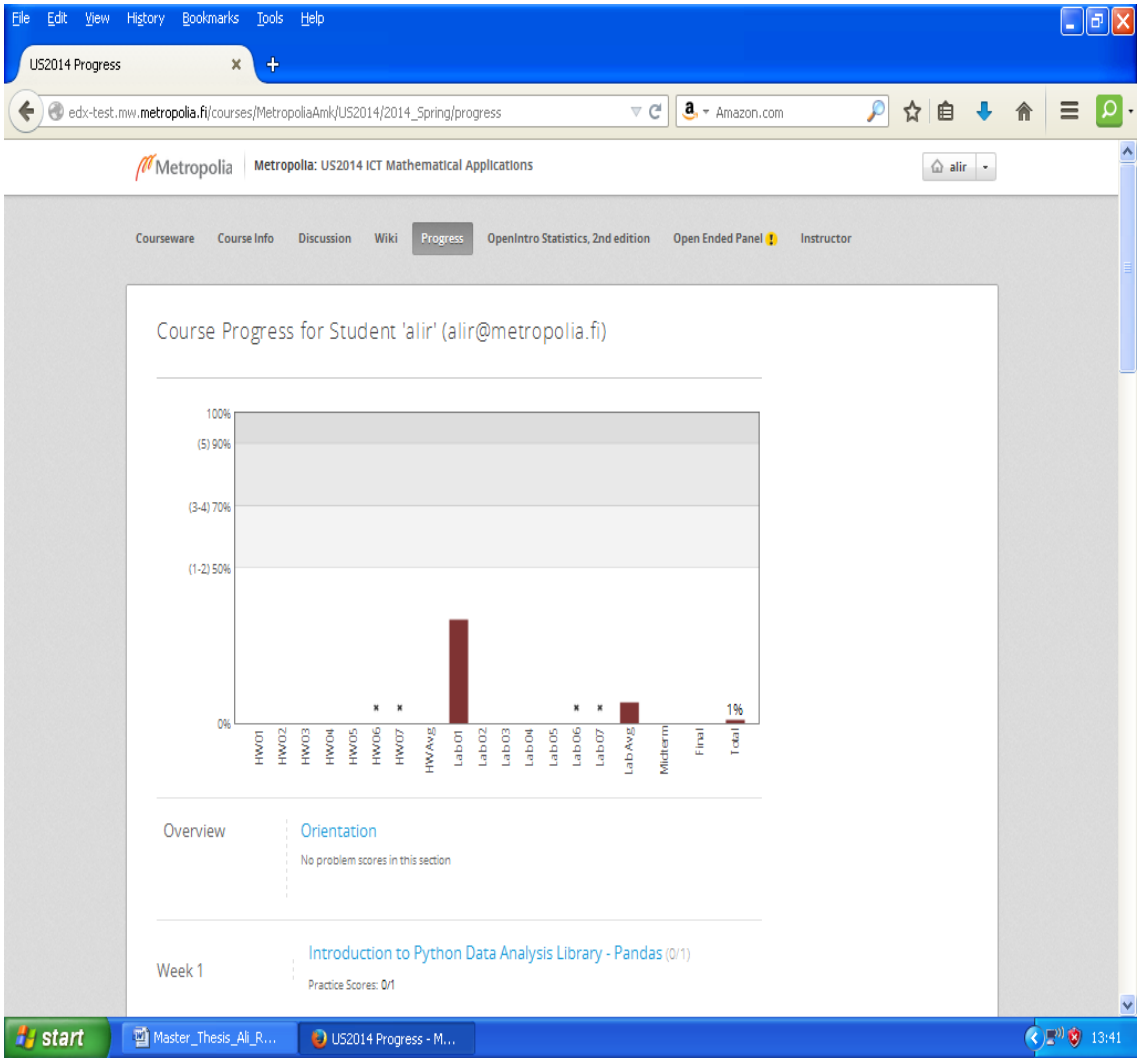
Appendix 5.

Wiki page of ICT Mathematical Application course



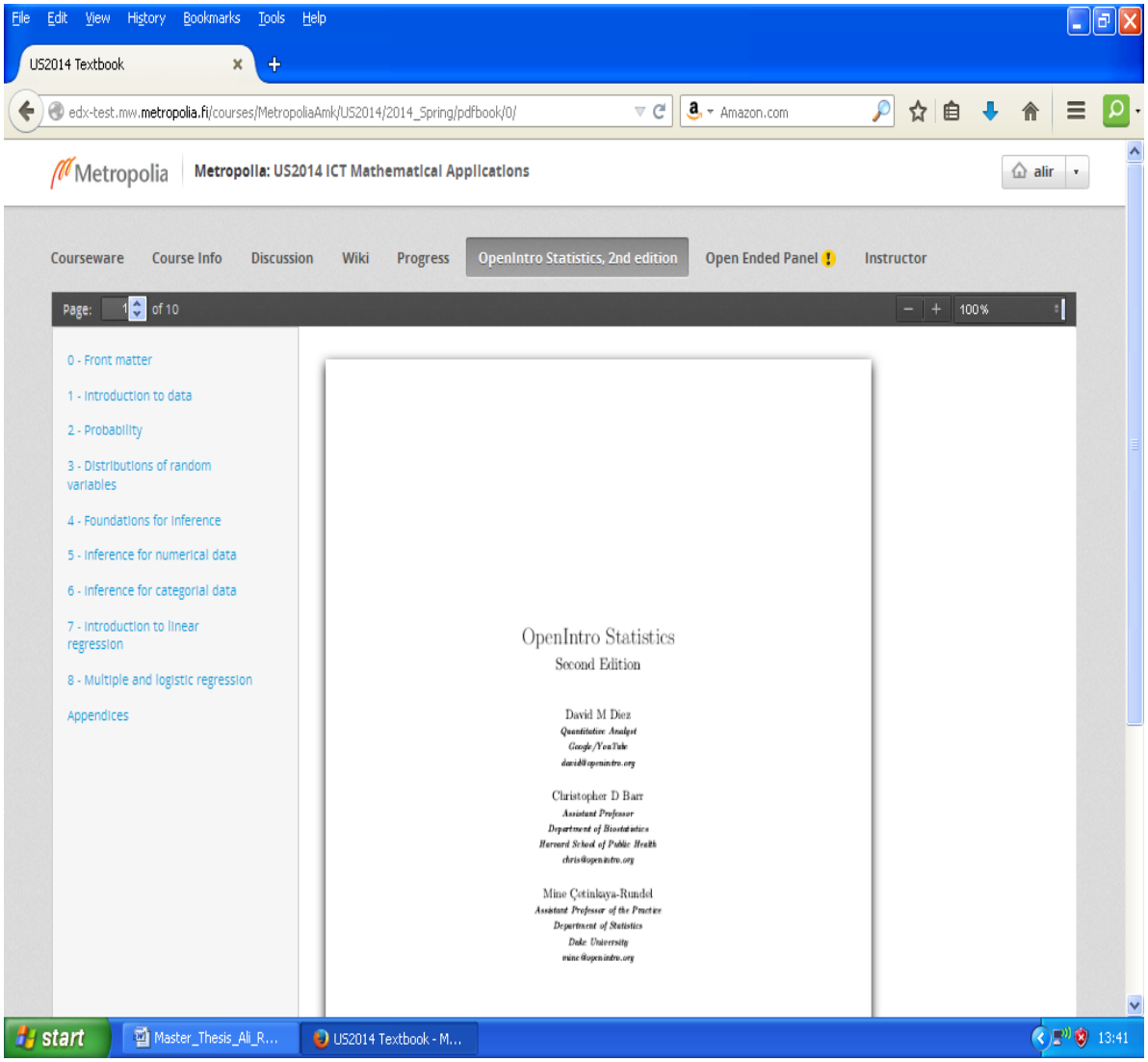
Appendix 6.

Progress page of ICT Mathematical Application course



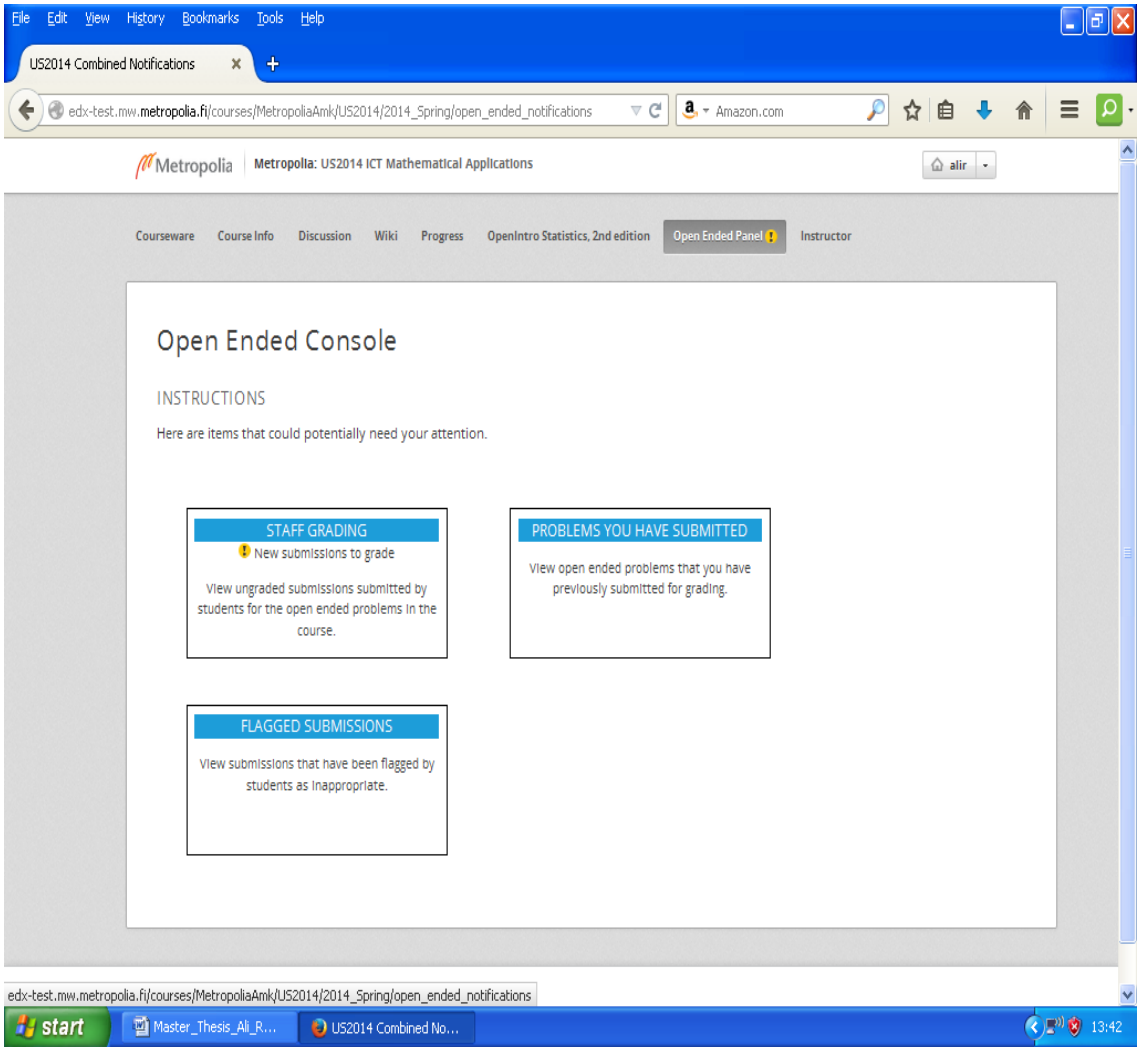
Appendix 7.

Downloaded e-material page of ICT Mathematical Application course



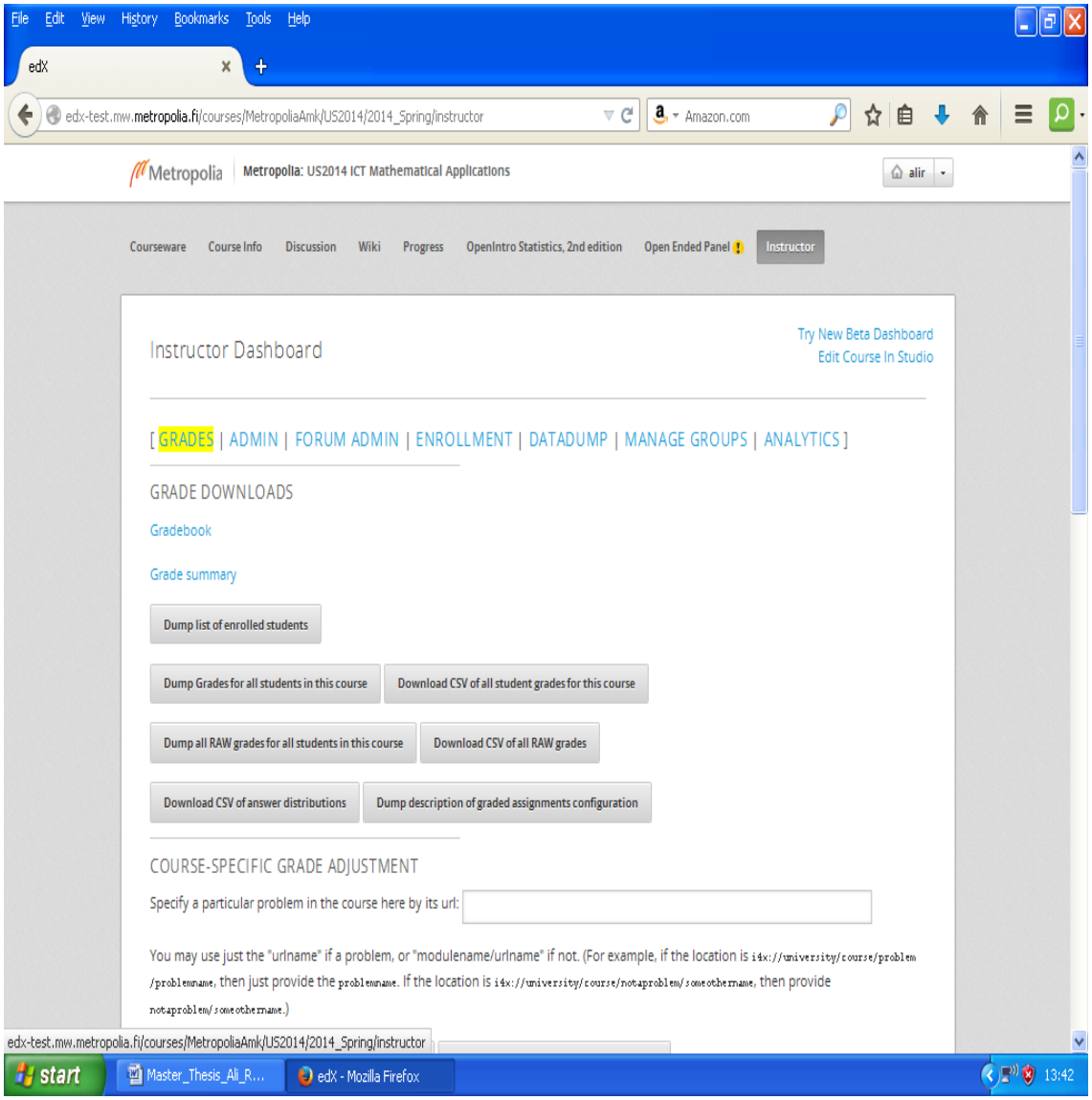
Appendix 8.

Open Ended Panel page of ICT Mathematical Application course



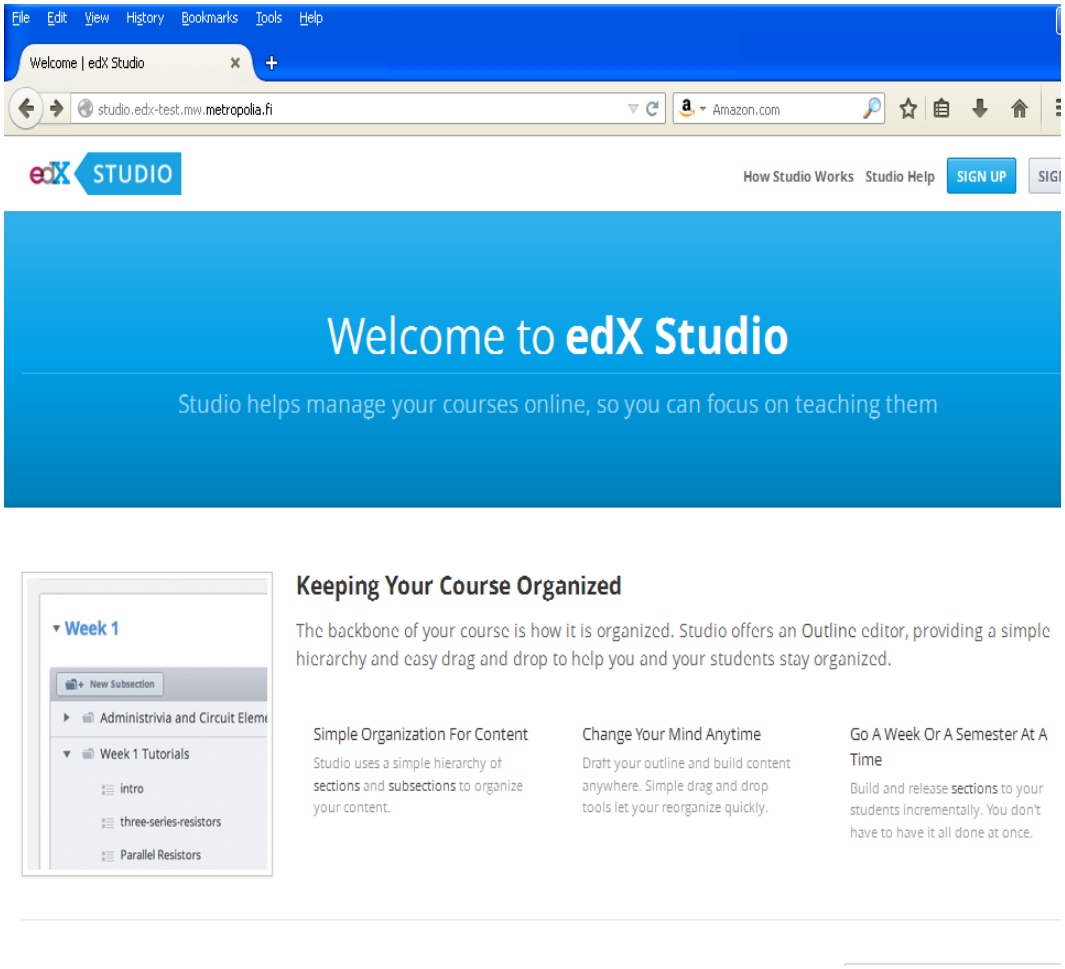
Appendix 9.

Instructor page of ICT Mathematical Application course



Appendix 10.

Studio, EdX online editor page at Metropolia



Appendix 11.

Example of Python labs

Lab 2: Probability

Basketball players who make several baskets in succession are described as having a “hot hand”. Fans and players have long believed in the hot hand phenomenon, which refutes the assumption that each shot is independent of the next. However, a 1985 paper by Gilovich, Vallone, and Tversky collected evidence that contradicted this belief and showed that successive shots are independent events†. This paper started a great controversy that continues to this day, as you can see by Googling “hot hand basketball”.

We do not expect to resolve this controversy today. However, in this lab we’ll apply one approach to answering questions like this. The goals for this lab are to (1) think about the effects of independent and dependent events, (2) learn how to simulate shooting streaks in R, and (3) to compare a simulation to actual data in order to determine if the hot hand phenomenon appears to be real.

Getting Started
Our investigation will focus on the performance of one player: Kobe Bryant of the Los Angeles Lakers. His performance against the Orlando Magic in the 2009 NBA finals earned him the title “Most Valuable Player” and many spectators commented on how he appeared to show a hot hand. Let’s load some data from those games and look at the first several rows.

```
%pylab inline
from __future__ import division
import pandas as pd
```

```
file =
"http://users.metropolia.fi/~tommiluk/Notebooks/ICTMath/kobe.csv"
sep = ";"
kobe = pd.read_csv(file, sep)
```

```
kobe.head()
```

In this data frame, every row records a shot taken by Kobe Bryant. If he hit the shot (made a basket), a hit, H, is recorded in the column named basket, otherwise a miss, M, is recorded. Just looking at the string of hits and misses, it can be difficult to gauge whether or not it seems like Kobe was shooting with a hot hand. One way we can approach this is by considering the belief that hot hand shooters tend to go on shooting streaks. For this lab, we define the length of a shooting streak to be the number of consecutive baskets made until a miss occurs.

For example, in Game 1 Kobe had the following sequence of hits and misses from his nine shot attempts in the first quarter:

H M | M | H H M | M | M | M

To verify this use the following command:

```
kobe.columns

kobe.basket.iloc[0:9]
```

Within the nine shot attempts, there are six streaks, which are separated by a “j” above. Their lengths are one, zero, two, zero, zero, zero (in order of occurrence).

> Exercise 1 What does a streak length of 1 mean, i.e. how many hits and misses are in a streak of 1? What about a streak length of 0?

The custom function calc_streak may be used to calculate the lengths of all shooting streaks and then look at the distribution.

```
def calc_streak(x):
    L = size(x)
    i = 0
    y = zeros(1)
    for n in range(L):
        if x[n] == True:
            y[i] = y[i] + 1
        else:
            i = i + 1
            y = append(y, 0)
    return int32(y)

x = (kobe.basket == "H").values
x

y = calc_streak(x)
y

s = pd.Series(y)
s
```

```
s.value_counts()

s.value_counts().plot(kind = 'bar')
```

Note that instead of making a histogram, we chose to make a bar plot from a table of the streak data. A bar plot is preferable here since our variable is discrete – counts – instead of continuous.

> Exercise 2 Describe the distribution of Kobe's streak lengths from the 2009 NBA finals. What was his typical streak length? How long was his longest streak of baskets?

Compared to What?

We've shown that Kobe had some long shooting streaks, but are they long enough to support the belief that he had hot hands? What can we compare them to?

To answer these questions, let's return to the idea of independence. Two processes are independent if the outcome of one process doesn't affect the outcome of the second. If each shot that a player takes is an independent process, having made or missed your first shot will not affect the probability that you will make or miss your second shot.

A shooter with a hot hand will have shots that are not independent of one another. Specifically, if the shooter makes his first shot, the hot hand model says he will have a higher probability of making his second shot.

Let's suppose for a moment that the hot hand model is valid for Kobe. During his career, the percentage of time Kobe makes a basket (i.e. his shooting percentage) is about 45%, or in probability notation,

$$P(\text{shot 1 = H}) = 0.45$$

If he makes the first shot and has a hot hand (not independent shots), then the probability that he makes his second shot would go up to, let's say, 60%,

$$P(\text{shot 2 = H} \mid \text{shot 1 = H}) = 0.60$$

As a result of these increased probabilities, you'd expect Kobe to have longer streaks. Compare this to the skeptical perspective where Kobe does not have a hot hand, where each shot is independent of the next. If he hit his first shot, the probability that he makes the second is still 0.45.

$$P(\text{shot 2 = H} \mid \text{shot 1 = H}) = 0.45$$

In other words, making the first shot did nothing to affect the probability that he'd make his second shot. If Kobe's shots are independent, then he'd have the same probability of hitting every shot regardless of his past shots: 45%.

Now that we've phrased the situation in terms of independent shots, let's return to the question: how do we tell if Kobe's shooting streaks are long enough to indicate that he has hot hands? We can compare his streak lengths to someone without hot hands: an independent shooter.

Simulations

While we don't have any data from a shooter we know to have independent shots, that sort of data is very easy to simulate. In a simulation, you set the ground rules of a random process and then the computer uses random numbers to generate an outcome that adheres to those rules. As a simple example, you can simulate flipping a fair coin with the following.

```
randint(2) < 1
```

The function randint draws one slip from the hat and tells us if it was a head or a tail.

Run the second command listed above several times. Just like when flipping a coin, sometimes you'll get a heads, sometimes you'll get a tails, but in the long run, you'd expect to get roughly equal numbers of each.

```
randint(2, size = 10) < 1
```

If you wanted to simulate flipping a fair coin 100 times, you could either run the function 100 times or, more simply, adjust the size argument, which governs how many samples to draw.

```
c = randint(2 ,size=100) < 1
s1 = pd.Series(c)
s1.head()
```

To view the results of this simulation, count up the number of heads and tails.

```
s1.value_counts()
```

Since there are only two elements in outcomes, the probability that we "flip" a coin and it lands heads is 0.5. Say we're trying to simulate an unfair coin that we know only lands heads 20% of the time. We can adjust for this by adjusting

the maximum of randint to 100 and comparing that value to 20, which provides a vector of two probability weights.

```
s2 = pd.Series(randint(100 , size = 100) < 20)
s2.value_counts()
```

This indicates that for the two outcomes vector, we want to select the first one, heads, with probability 0.2 and the second one, tails with probability 0.8.*

> Exercise 3 In your simulation of flipping the unfair coin 100 times, how many flips came up heads?

In a sense, we've shrunk the size of the slip of paper that says "heads", making it less likely to be drawn and we've increased the size of the slip of paper saying "tails", making it more likely to be drawn. When we simulated the fair coin, both slips of paper were the same size.

Simulating the Independent Shooter

Simulating a basketball player who has independent shots uses the same mechanism that we use to simulate a coin flip. To simulate a single shot from an independent shooter with a shooting percentage of 50% we type,

```
sim_basket = pd.Series(randint(100 , size = 100) < 50)
```

To make a valid comparison between Kobe and our simulated independent shooter, we need to align both their shooting percentage and the number of attempted shots.

> Exercise 4 What change needs to be made to the sample function so that it reflects a shooting percentage of 45%? Make this adjustment, then run a simulation to sample 133 shots.

Note that we've named the new vector sim_basket, the same name that we gave to the previous vector reflecting a shooting percentage of 50%.
With the results of the simulation saved as sim_basket, we have the data necessary to compare Kobe to our independent shooter. We can look at Kobe's data alongside our simulated data.

```
kobe.basket
sim_basket
```

Both data sets represent the results of 133 shot attempts, each with the same shooting percentage of 45%. We know that our simulated data is from a shooter that has independent shots. That is, we know the simulated shooter does not have a hot hand.

On your own

Comparing Kobe Bryant to the Independent Shooter
Using calc_streak, compute the streak lengths of sim_basket.

1. Describe the distribution of streak lengths. What is the typical streak length for this simulated independent shooter with a 45% shooting percentage? How long is the player's longest streak of baskets in 133 shots?
2. If you were to run the simulation of the independent shooter a second time, how would you expect its streak distribution to compare to the distribution from the question above? Exactly the same? Somewhat similar? Totally different? Explain your reasoning.
3. How does Kobe Bryant's distribution of streak lengths from page 2 compare to the distribution of streak lengths for the simulated shooter? Using this comparison, do you have evidence that the hot hand model fits Kobe's shooting patterns? Explain.
4. What concepts from the textbook are covered in this lab? What concepts, if any, are not covered in the textbook? Have you seen these concepts elsewhere, e.g. lecture, discussion section, previous labs, or homework problems? Be specific in your answer.

†"The Hot Hand in Basketball: On the Misperception of Random Sequences", Gilovich, T., Vallone, R., Tversky, A., 1985. Cognitive Psychology, 17, pp. 295-314.

*Another way of thinking about this is to think of the outcome space as a bag of 10 chips, where 2 chips are labeled "head" and 8 chips "tail". Therefore at each draw, the probability of drawing a chip that says "head" is 20%, and "tail" is 80%.

Appendix 11.

Lab 2 solution (solved by Python)

Lab 2 - Introduction to Data¶

ICT Mathematical Applications, Spring 2014

Helsinki Metropolia University of Applied Sciences
Adapted from: OpenIntro Statistics, www.openintro.org

```
In [139]:
%pylab inline
from __future__ import division
import pandas as pd
Populating the interactive namespace from numpy and matplotlib
```

```
In [140]:
file=
"http://users.metropolia.fi/~tommiluk/Notebooks/ICTMath/kobe.csv"
sep = ";"
kobe = pd.read_csv(file, sep)
In [141]:
kobe.head()
Out[141]:
```

	vs	game	quarter	time	description	basket
1	ORL	1	1	9:47	Kobe Bryant makes 4-foot two point shot	H
2	ORL	1	1	9:07	Kobe Bryant misses jumper	M
3	ORL	1	1	8:11	Kobe Bryant misses 7-foot jumper	M
4	ORL	1	1	7:41	Kobe Bryant makes 16-foot jumper (Derek Fisher...	H
5	ORL	1	1	7:03	Kobe Bryant makes driving layup	H

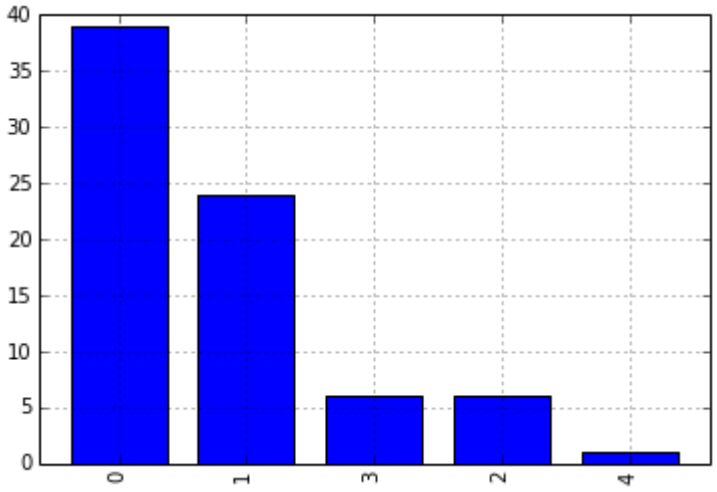
5 rows × 6 columns

```
In [142]:
kobe.columns
Out[142]:
Index([u'vs', u'game', u'quarter', u'time', u'description', u'basket']
, dtype='object')
In [143]:
kobe['basket'].iloc[0:9]
Out[143]:
1    H
2    M
3    M
```

```
4    H
5    H
6    M
7    M
8    M
9    M
Name: basket, dtype: object
In [177]:
(kobe.basket.iloc[0:9] == "H")
Out[177]:
1     True
2    False
3    False
4     True
5     True
6    False
7    False
8    False
9    False
Name: basket, dtype: bool
In [145]:
(kobe.basket == "H").value_counts()
Out[145]:
False    75
True     58
dtype: int64
In [146]:
# (kobe.basket == "H").values
Out[146]:
array([ True, False, False,  True,  True, False, False, False, False,
        True,  True,  True, False,  True,  True, False, False,  True,
        True,  True, False, False,  True, False,  True,  True,  True,
       False, False, False, False, False, False,  True, False,  True,
       False, False,  True,  True,  True,  True, False,  True, False,
       False,  True, False, False,  True, False, False,  True, False,
        True,  True, False, False,  True, False,  True,  True, False,
        True, False, False, False,  True, False, False, False, False,
        True, False,  True, False, False,  True, False, False,  True,
        True, False, False, False, False,  True,  True,  True, False,
       False,  True, False, False,  True, False,  True,  True, False,
        True, False, False,  True, False, False, False,  True, False,
        True,  True,  True, False,  True,  True,  True, False,  True,
       False,  True, False, False, False, False, False, False,  True,
       False,  True, False, False, False, False,  True], dtype=bool)
In [147]:
# cumsum((kobe.basket == "H").values)
Out[147]:
```

```
array([ 1,  1,  1,  2,  3,  3,  3,  3,  3,  4,  5,  6,  6,  7,  8,  8,
8,
        9, 10, 11, 11, 11, 12, 12, 13, 14, 15, 15, 15, 15, 15, 15, 15,
16,
       16, 17, 17, 17, 18, 19, 20, 21, 21, 22, 22, 22, 23, 23, 23, 24,
24,
       24, 25, 25, 26, 27, 27, 27, 28, 28, 29, 30, 30, 31, 31, 31, 31,
32,
       32, 32, 32, 32, 33, 33, 34, 34, 34, 35, 35, 35, 36, 37, 37, 37,
37,
       37, 38, 39, 40, 40, 40, 41, 41, 41, 42, 42, 43, 44, 44, 45, 45,
45,
       46, 46, 46, 46, 47, 47, 48, 49, 50, 50, 51, 52, 53, 53, 54, 54,
55,
       55, 55, 55, 55, 55, 56, 56, 57, 57, 57, 57, 57, 58])
In [148]:
# diff(cumsum((kobe.basket == "H").values))
Out[148]:
array([0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0, 1, 1, 1, 0, 0,
1, 0,
       1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 0,
0, 1,
       0, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 1,
0, 0,
       0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0,
1, 0,
       0, 1, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 0, 1, 0, 1, 1, 1, 0, 1, 1,
1, 0,
       1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1])
In [149]:
def count_streak(x):
    L = size(x)
    i = 0
    y = zeros(1)
    for n in range(L):
        if x[n] == True:
            y[i] = y[i] + 1
        else:
            i = i + 1
            y = append(y, 0)
    return int32(y)
In [150]:
count_streak((kobe.basket == "H").values)
Out[150]:
array([1, 0, 2, 0, 0, 0, 3, 2, 0, 3, 0, 1, 3, 0, 0, 0, 0, 0, 1, 1, 0,
4, 1,
```

```
       0, 1, 0, 1, 0, 1, 2, 0, 1, 2, 1, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1,
0, 2,
       0, 0, 0, 3, 0, 1, 0, 1, 2, 1, 0, 1, 0, 0, 1, 3, 3, 1, 1, 0, 0,
0, 0,
       0, 1, 1, 0, 0, 0, 1])
In [151]:
streaks = pd.Series(count_streak((kobe.basket == "H").values))
In [152]:
streaks.value_counts()
Out[152]:
0    39
1    24
3     6
2     6
4     1
dtype: int64
In [153]:
streaks.value_counts().plot(kind = 'bar')
Out[153]:
<matplotlib.axes.AxesSubplot at 0xcb56518>
```



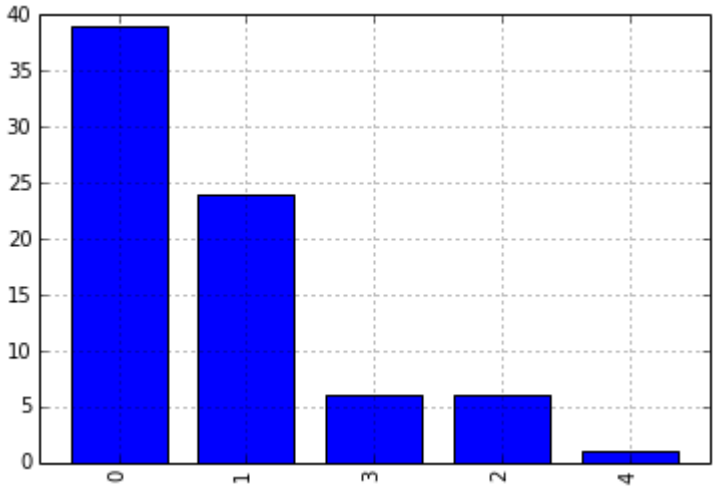

```
In [154]:
# Alternative way
file="http://users.metropolia.fi/~tommiluk/Notebooks/ICTMath/kobe_stre
ak.csv"
sep = ";"
kobe_streak = pd.read_csv(file, sep)
kobe_streak.iloc[0:9]

kobe_streak.dtypes

int32(kobe_streak['x'])
```

```
kobe_streak['x'].values

kobe_streak['x'].value_counts().plot(kind = 'bar')
Out[154]:
<matplotlib.axes.AxesSubplot at 0xcb78e10>
```

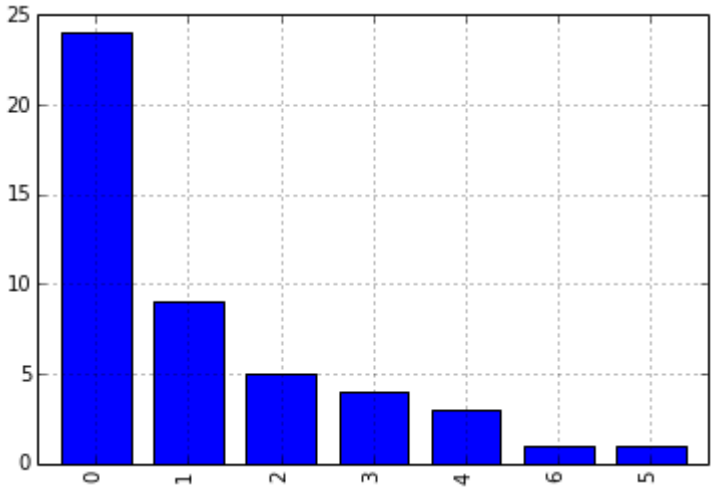



```
In [178]:
randint(2)
Out[178]:
0
In [182]:
randint(2, size = 10) < 1
Out[182]:
array([ True,  True, False, False,  True,  True,  True, False, False,
True], dtype=bool)
In [183]:
s1 = pd.Series(randint(2 ,size=100))
In [184]:
s1.head()
Out[184]:
0    0
1    1
2    1
3    0
4    0
dtype: int32
In [185]:
s1.value_counts()
Out[185]:
1    54
0    46
dtype: int64
In [186]:
```

```
s2 = pd.Series(np.random.randint(10 ,size=100))
In [161]:
s2.value_counts()
Out[161]:
6    13
4    12
0    11
8    10
7    10
2    10
9     9
5     9
3     9
1     7
dtype: int64
In [162]:
(s2 < 2).value_counts()
Out[162]:
False    82
True     18
dtype: int64
In [163]:
s3 = pd.Series(np.random.randint(100 ,size=100))
(s3 < 45).head()
Out[163]:
0    False
1    False
2     True
3     True
4    False
dtype: bool
In [164]:
(s3 < 45).value_counts()
Out[164]:
False    58
True     42
dtype: int64
In [165]:
x = randint(2, size = 100)
count_streak(x < 1)

Out[165]:
array([2, 1, 4, 0, 0, 0, 0, 0, 6, 0, 0, 0, 0, 0, 0, 5, 2, 1, 3, 0, 1,
0, 3,
       2, 0, 0, 0, 2, 1, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 3, 1, 1, 0,
1, 0,
       2, 5, 1, 0])
```

```
In [166]:
x = randint(100, size = 300)
count_streak(x < 45)
Out[166]:
array([ 1,  1,  1,  0,  0,  0,  2,  1,  2,  1,  5,  0,  2,  0,  0,  1,
0,
        1,  2,  0,  3,  2,  1,  0,  2,  0,  0,  0,  0,  0,  1,  1,  2,
1,
        0,  1,  0,  5,  0,  2,  0,  0,  0,  0,  1,  1,  0,  0,  0,  0,
10,
        1,  0,  0,  3,  2,  1,  0,  1,  1,  3,  1,  0,  1,  0,  0,  1,
1,
        2,  1,  0,  0,  2,  0,  3,  1,  0,  0,  0,  0,  0,  0,  0,  0,
4,
        1,  0,  1,  0,  2,  4,  0,  1,  0,  0,  0,  1,  4,  0,  2,  0,
3,
        0,  1,  0,  0,  2,  2,  1,  0,  1,  1,  0,  3,  0,  0,  0,  0,
0,
        0,  4,  1,  2,  3,  0,  1,  1,  0,  0,  0,  0,  1,  1,  1,  1,
0,
        0,  2,  0,  0,  0,  0,  0,  0,  0,  0,  1,  1,  1,  0,  0,  1,
1,
        1,  1,  3,  0,  0,  1,  0])
In [174]:
s4 = pd.Series(np.random.randint(100 ,size=100))
s5 = pd.Series(count_streak(s4 < 45))
In [175]:
s5.value_counts()
Out[175]:
0    24
1     9
2     5
3     4
4     3
6     1
5     1
dtype: int64
In [176]:
s5.value_counts().plot(kind = "bar")
Out[176]:
<matplotlib.axes.AxesSubplot at 0xd0f56a0>
```


25
20
15
10
5
0
0
1
2
3
4
6
5