

# Online Learning Era: Exploring the Most Decisive Determinants of MOOCs in Taiwanese Higher Education

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Because the development of Taiwanese Massive Open Online Course (MOOCs) websites is at this moment full of vitality, this research employs a series of analytical cross-measurements of Quality Function Deployment method of House of Quality (QFD-HOQ) model and Multiple Criteria Decision Making (MCDM) methodology to cross-evaluate the weighted questionnaire results based on three major analytical perspectives (higher education student's desires, online-learning technological functions and online-education scholar's considerations) to assess the interplays between the WHATs (students' online-learning interests) and the HOWs (the technological online-education measures), based on the higher research reliability and validity. According to the measured results, user's completely unrestricted operation, convenience, connectionization, openness and course complete rate are the most decisive five technological online-education determinants of MOOCs websites based on weighted-measurements of expert's questionnaire among WHATs and HOWs cross-evaluated matrix of QFD-HOQ model that academically resupplies to research gaps of MOOCs fields and empirically contributes to the relative industries.

*Keywords:* Massive Open Online Course (MOOCs), online education, quality function deployment method of house of quality (QFD-HOQ) model, multiple criteria decision making (MCDM) methodology

## INTRODUCTION

As online websites like Facebook and YouTube have been popularized by the world, people today can not only one-way surf the internet and download public up-to-date news and knowledge but they can also two-way share and upload private messages and information from various websites in anytime and anywhere through various wireless technology devices, such as notebooks, tablets, smart phones and so forth (Bonino, 2012; British Broadcasting Corporation [BBC], 2012; Gao, Luo, & Zhang, 2012; Kukulska-Hulme & Traxler, 2007; Winters, 2007). Following the rapid

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development of wireless and internet technologies, majority of people have commenced to not only search and obtain information and latest news but to also discuss and study professional learning in fields such as science, engineer, architect, medicine, law, management and others through the use of open education characteristic of online learning (Budak & Kaygin, 2015). Open education characteristic of online learning means that each participant is not only an educator but also a learner because they can provide their own professional knowledge or the latest information as well as study other participant's sciences in the online learning courses (Bell, 2010b). In particular, more students of higher education have preferred to take diversified professional lessons in various online learning platforms without demographic, economic, and geographical constraints because they prefer not to be restricted in the traditionally physical face-to-face educational environments (Bremer, 2012). The result has been that online learning has gradually played a greater critical role in the effectiveness and efficiency of studying behaviors of students in higher education. In 2008, Massive Open Online Course ("MOOCs") (Ardis & Henderson, 2012; Cabiria, 2012) was generated through the cross-consolidated development of various digital courses from various world-renowned, world-class universities such as Stanford University ("Stanford-U"), Harvard University ("Harvard-U") (Bates, 2013), Massachusetts Institute of Technology ("MIT") (Butin, 2012; Frank, 2012) and University of California at Berkeley ("UC-Berkeley") and etc.

Nowadays, the most popular and professional MOOCs websites are Udacity, Coursera and edX. In February 2012, Udacity was founded and supported by Stanford-U and Charles River Ventures (a venture capital firm) as a for-profit institution of higher learning. As specified in Udacity's website on April 2014, there are 1.6 million individual users as of April 2014 who are registered in 12 full courses and 26 free courseware into various related subjects. Furthermore, Udacity has consolidated with Georgia Institute of Technology and AT&T to provide the first "massive online open degree" in computer science subject to online individual users with a program costs of \$7,000 USD. In April 2012, Coursera was pioneered by computer science professors, Andrew Ng and Daphne Koller, from Stanford-U as a for profit higher learning institution in order to provide online learning courses in diversified subjects, including physics, engineering, humanities, medicine, biology, social sciences, mathematics, business, computer science and so further. At present, Coursera supplies more than 1,000 courses from 117 global educational institutions to more than 12 million enrolled members from 190 countries. In September 2012, edX was instituted and supported by three world-class universities (Harvard-U, MIT and UC-Berkeley) as a not-for-profit by employing their open-source technology

### **State of the literature**

- The origin and develop tendency and nine potential advantages and five disadvantages of MOOCs websites are concluded in this research; however, exploring the potential determinants of MOOCs websites is a lack of current literatures.
- The specific concept and characteristics and technically evaluated processes of QFD-HOQ are integrated in this research; however, its application in MOOCs is a lack of current literature.
- The initial development of EM, FT and TOPSIS of MCDM are orderly discussed and various applications of these approaches for weight-measurements are further discussed in this research.

### **Contribution of this paper to the literature**

- An effective evaluation model is instituted to efficiently assay the interplays between WHATs (students' online-learning interests) and HOWs (the technological online-education measures).
- Based on complex measurements, user's completely unrestricted operation, convenience, connectionization, openness and course complete rate are the most decisive five technological online-education determinants of MOOCs websites that academically re-supplies to the MOOCs research gaps and empirically contributes to industries.
- As for reinforcement of research reliability, EM, FT and TOPSIS approaches of MCDM methodology are successfully introduced to measure the weighted-measurements of expert's questionnaire of QFD-HOQ model.

platforms (Harvardx, MITx and Berkeleyx) in order to provide the online contents and materials of these courses to global wireless users as well as to supply the university faculty in conducting more classroom and laboratory experiences of research and teaching without the time restriction and campus limitation. Consequently, the comparisons of these three MOOCs websites are described in the Table 1.

In Taiwan, the “i-Taiwan” (Wi-Fi transmission system) and the fourth generation of mobile phone mobile communication technology standards (“4G”) were completed by the Taiwanese National Development Council in 2014. These enhanced technologies have resulted in that 98.7% of Taiwanese spending an average of 2.8 hours daily on the internet according to the 2014 annual official report of the Taiwanese Institute of Information Industry (III) incorporated as a

**Table 1.** Competitions there MOOCs websites of Udacity, Coursera and edX

	 Udacity ( <a href="https://www.udacity.com/">https://www.udacity.com/</a> )	 Coursera ( <a href="https://www.coursera.org/">https://www.coursera.org/</a> )	 edX ( <a href="https://www.edx.org/">https://www.edx.org/</a> )
<b>Founded Time</b>	February 2012	April 2012	September 2012
<b>Subject Field</b>	Computer science	Academic subjects	Academic subjects
<b>Courses</b>	38	647	181
<b>Supported University</b>	Stanford-U	Stanford-U	Harvard-U, MIT and UC-Berkeley.
<b>Main Fee</b>	Certificate fee	Certificate, exam and tuition fees	Certificate fee
<b>Main Platform Functions</b>	Course syllabus, course captions and videos, Quiz self-evaluation, assignment-discussion, class-forum, online laboratory and so on.	Course syllabus, course captions and videos, Quiz self-evaluation, assignment-discussion, class-forum, online laboratory and so on.	Course syllabus, course captions and videos, Quiz self-evaluation, assignment-discussion, class-forum, online laboratory and so on.
<b>Pros</b>	<ol style="list-style-type: none"> <li>Each user is able to log in course through Facebook or Twitter platforms.</li> <li>It contains high-quality interactive operation function.</li> <li>A lot of courses are enough to cover various academic subjects.</li> <li>Each course contains multi-national language introductions in detail.</li> <li>Some courses offer the multi-national language subtitles.</li> <li>Some courses provide the “sign-up” attendance certificate.</li> <li>Some courses supply the exam-invigilation certificate to increase course reliability but users have to pay the related fees.</li> <li>It provides participant’s resume and job match services.</li> </ol>	<ol style="list-style-type: none"> <li>A lot of courses are enough to cover various academic subjects.</li> <li>Each course contains multi-national language introductions in detail.</li> <li>Some courses offer the multi-national language subtitles.</li> <li>Some courses provide the “sign-up” attendance certificate in 298 courses.</li> <li>Some courses supply the exam-invigilation certificate in 6 order to increase course reliability but users have to pay the related fees.</li> <li>Enterprises can pay to run their own training courses.</li> </ol>	<ol style="list-style-type: none"> <li>It is not-for-profit.</li> <li>A lot of courses are enough to cover various college professional subjects.</li> <li>Each course contains multi-national language introductions in detail.</li> <li>Some courses offer the multi-national language subtitles.</li> <li>Some courses provide the “sign-up” attendance certificate in 49 courses.</li> <li>Some courses supply the exam-invigilation certificate to increase course reliability but users have to pay the related fee.</li> </ol>
<b>Cons</b>	<ol style="list-style-type: none"> <li>The subjects are confined in the related computer science field.</li> <li>The English still are main educational language in the most of courses.</li> <li>The most of participants do not complete the selected courses on requested schedule.</li> </ol>	<ol style="list-style-type: none"> <li>The interactive evaluation function between each user is still not effective and efficient.</li> <li>The most of participants do not complete the selected courses on requested schedule.</li> </ol>	<ol style="list-style-type: none"> <li>The pre-course evaluation function between each user still cannot be manipulated before effective and efficient.</li> <li>The most of participants do not complete the selected courses on requested schedule.</li> </ol>

Non-Governmental Organization (NGO) in 1979. Based on the advantages of wireless and internet technologies in Taiwan, the Taiwanese Ministry of Education has officially commenced in implementing a series of online learning policies and subsidies for each institute of higher education to stimulate them in order to create diversified tradition-classroom and online-learning platforms to empirically offer various online learning strategies and policies, online-learning programs. In February 2013, the Taiwanese Ministry of Education announced the execution of the "Digital Learning Implement Plan" that covers three brief online-learning hardware infrastructures and two main online-learning software models. These online-learning hardware infrastructures: (1) Promotion Bandwidth Efficiency of Education Academic Research Infrastructure: the 100 Gigabytes ("GB") Transmission Bandwidth has been established in entire Taiwan infrastructure and gradually expand the campus transmission bandwidth in each educational institute year-by-year; (2) Promotion Wireless Transmission Quality on Campus: the online-learning coverage in each Taiwanese elementary, junior and senior high school have to achieve 90 percent coverage by 2018 with wireless transmission bandwidth in each educational Taiwanese institute reaching 500 Megabytes ("MB") by 2018 and (3) Integration of Cloudy Online-learning Resource: The diversified functions in "Cloudy Education System" of Ministry of Education will be created and applied in the educational platforms of Taiwanese educational institutes for each teacher and student and those functions are "Parent and Child e-mail", "Parent and Child Information", "Parent and Child Communication Book", "Parent and Child Bookcase", "Parent and Child Video-folder" and "Parent and Child Market" and "Parent and Child Encyclopedia" and so on. Continuously, the two main online-learning models are (1) Digital Comprehensive School Development Plan and (2) MOOCs Plan. Furthermore, almost all Taiwanese colleges and universities have established various online learning platforms and have also constructed wireless internet services on their campuses, according to the 2014 annual official report of Department of Statistics of Taiwanese Ministry of Education. More and more higher-education students utilize MOOCs platforms to obtain diversified information and knowledge by taking the cross-subject courses of MOOCs systems that result in MOOCs have gradually played a critical role on in the studying behaviors and procedures of Taiwanese higher education students. The current five crucial MOOCs websites in Taiwan are briefly described in Table 2.

Consequently, "how to provide the most convenient online learning courses" (Bull, 2012; Kirkwood, 2010) and "how to stimulate the student's studying interests in the online learning courses" (Carey, 2013; Kim & Cho, 2015) have both been the research mainstream in the contemporary online learning era. Beyond making the comprehensive overlook and survey on the relative researches in the online learning relative research fields (Anderson & McGreal, 2012; Casey, 2012; DeWaard et al., 2011; Han, Yalvac, Capraro, & Capraro, 2015; Hyman, 2012), most of the related researches emphasizes the traditional physical course's requests, such as the course's professionalization, evaluation and certification (DeWaard, 2011; Chamberlin & Parish, 2011). There is no research that can comprehensively analyze and further explore the most decisive technological determinants of MOOCs website in Higher Education by discussing and evaluating the interactive dependences and relationships between the students' online learning elements and the technological online-educational factors (Chamberlin & Parish, 2011; Christensen, Johnson, & Horn, 2008; DeWaard et al., 2011; Downes, 2007a; Kohil & Kumar, 2011). For this reason, in terms of the increment of research validity, this research employs the analytical cross-measurements of Quality Function Deployment method of House of Quality ("QFD-HOQ") model and the statistics of the Multiple Criteria Decision Making ("MCDM") methodology to assess the independences and relationships between the students' online-learning interests (WHATs) and the

**Table 2.** Overview of Taiwanese MOOCs websites

MOOCs in Taiwanese	Brief Description
<p>“III Proera” (Taiwanese Institute of Information Industry, III)</p> 	<p>Proera was founded by Taiwanese Institute of Information Industry (III) through a cross-cooperation with the Association of e-Learning (AEL) and Tamkang University to provide various digital educational platforms. Additionally, Proera is going to cooperate with sharecourse in order to offer a more effective and efficient online-learning website.</p>
<p>(<a href="http://www.proera.com.tw/">http://www.proera.com.tw/</a>)</p> <p>“Homogeneous Educational Platform (HEP)”</p> 	<p>HEP was founded by the Alliance Cultural Foundation (ACF) and Social Enterprise Insights (SEI) and it has been utilized to share more than 2,000 Taiwanese teaching videos of related mathematics and science subjects in over 60 classes. It further provides a badge system for teachers in order to stimulate student’s study interests and fulfillment.</p>
<p>(<a href="http://www.junyiacademy.org/">http://www.junyiacademy.org/</a>)</p> <p>“NTHU sharecourse” (National Tsing Hua University, NTHU)</p> 	<p>The National Tsing Hua University founded the NetXtream Technology Company on August 2008 invented the “sharerom” for expanding the online discuss space, sharerom and then, the sharelive for relaying a radio or TV broadcast. After the development of NTHU sharecourse, more technological functions were created and these are (1) “sharenet” was discovered for sharing users’ experience and thinking and furthermore, sharetalk was initiated for multiple-user’s interactive video transmission and sharing. In particular, sharecourse also covers the teacher-student online interactive system for the connection between lecturers and students, user’s peer-reviewed system and word-and-video format assignment submission system. In February 2013, University System of Taiwan (UST) consolidated by National Tsing Hua University, National Chiao Tung University, National Yang-Ming University and National Central University, provides 13 courses of related Engineer subjects. Subsequently, National Central University utilized sharecourse platform and function to create “NCUx” system in order to offer pre-college course for 600 students from 15 senior high schools in Taoyuan City. As for the certification, sharecourse will issue the course credit certificates for the participants who have achieved the course requirements.</p>
<p>(<a href="http://www.sharecourse.net/sharecourse/">http://www.sharecourse.net/sharecourse/</a>)</p> <p>“NCTU ewant”</p> 	<p>National Chiao Tung University (“NCTU”) founded the technological platforms for MOOCs course in January 2013 and created the “ewant” MOOCs websites in association with four China universities (Shanghai Jiao Tong University, Xi’an Jiaotong University and Southwest Jiaotong University and Beijing Jiaotong University) to inaugurate the first online-learning education cooperation between China and Taiwan.</p>
<p>(<a href="http://www.ewant.org/">http://www.ewant.org/</a>)</p> <p>“NOU Taiwan LIFE”</p> 	<p>Taiwan LIFE was founded by National Chiao Tung University (“NCTU”) and National Open University (“NOU”) and currently provides 40 classes with the cooperation of 15 Taiwanese college and universities. Taiwanese Ministry of Education founded MOU to provide digital academic classes. The responsibility of the development of online and wireless transmission technologies was assigned to NCTU. In particular, subject-credit and degree certificates are legally able to issue through the evaluation system of the Taiwan LIFE online-learning platforms.</p>
<p>(<a href="http://taiwanlife.org/">http://taiwanlife.org/</a>)</p> <p>“NTU Coursera”</p> 	<p>In August 2013, National Taiwan University (“NTU”) first pioneered two Chinese MOOCs classes, “Possibility” and “Chinese Traditional History and Famous Person- Qin Shi Huang” that broke the English language learning barrier for of Taiwan participants. Furthermore, NTU continuously provide cross-subject classes, including, engineering graphics, optics foundation, Greece philosophy application, traditional Chinese notes – the dream of the red chamber and traditional Chinese history record - the historical records and such as.</p>
<p>(<a href="https://www.coursera.org/">https://www.coursera.org/</a>)</p>	

technological online-education measures (HOWs). Based on the original concept of QFD-HOQ, it was created in order to be able to assess each influenced element in the

product design process because QFD-HOQ can systematically consolidate the customer's requests and desires into the product design consideration through cross-measurements of weighted results from questionnaires between product design considerations and customer's wants (Chan, 2015; Chang & Wu, 2015; Eren, Bulut, & Bulut, 2015). Furthermore, in the light of addition of the research reliability, this research specifically applied three major analytical perspectives (higher education student's desires, online-learning technological functions and online-education scholar's considerations) in QFD-HOQ into the cross-evaluated QFD-HOQ measurements in order to synthetically explore the most critical determinants of MOOCs websites in the Taiwanese higher education sector (Coursera, 2013; Eilks, 2015).

## RELATIVE LITERATURES

In order to explore the most decisive determinants of MOOCs in Taiwanese higher education, this research cross-employs the QFD-HOQ model and Multiple Criteria Decision Making ("MCDM") methodology, including the Entropy Method ("EM"), the Fuzzy Theory ("FT") and the Technique for Order Preference by Similarity to Ideal Solution ("TOPSIS") approaches, to efficiently enhance research reliability and effectively refine the weight-measurements of expert's questionnaire of QFD-HOQ model. Essential concept of MOOCs, theoretical mode of the QFD-HOQ model and statistic method of MCDM methodology are discussed in the reviewing literatures of this research.

MOOCs is a free and open access courses supported by each online participant (Casey, 2008; Downes, 2007b; Liyanagunawardena, 2012) because each participant can be educator and learner in MOOCs websites without time, space, participation restrictions that definitely breaks through the various limitations of traditional physical courses, such as official filmed lectures, requested readings, and course problem sets and discussion and so on (Daniel, 2012). The original design concept of MOOCs was associated with two educational theoretical concepts of the open educational resources theory and the connectivist pedagogy theory (Bell, 2010a; Bell, 2010c; Kop & Carroll, 2012).and it is typical kind of online-learning substantial operation model through systematically providing the diversified educational courses and learning resources for the extensive wireless-technology users (Kop, Fournier, & Mak, 2011). Specifically, there are four characteristics of MOOCs: (1) freely educational resources: any individual wireless-technological user is easily able to utilize any educational resources in MOOCs, (2) completely unrestricted operation: each individual wireless-technological user is synthetically to operate any educational functions in MOOCs with time restriction and space limitation, (3) peer-review and group collaboration: each individual can utilize the internet technology platforms to easily implement group collaboration in order to eventually execute online peer-review to assess their online-studying course's consequences and (4) automated feedback: MOOCs offer objective auto-feedback function (such as quizzes and exams) to ensure the course's quality (Esposito, 2012; Sahin, Yenmez, & Erbas, 2015). In terms of developed history of MOOCs, the origin of MOOCs was produced by the correspondence and broadcast courses of distance education in the 1920s and in earlier stage of the digital age. Engelbart (1962) addressed the "Augmenting Human Intellect: A Conceptual Framework" to innovatively emphasize on that the computer is possible to assist individual studying as well as imply large-scale information exchange trend. The Open University in the United Kingdom commenced to provide distance education courses through the BBC television broadcasts in the 1970s which started on 3 January 1971 and continues to operate, at present, with around 250,000 students studying using a wide range of online channels. Joint Information Systems Committee (JISC, 2013) re-delivered that

traditional inflexible course syllable and lecture method will strangle student's studying motivation, interests and willing. For this reason, he further addressed that each education school have to take advanced technologies to solve this issue; especially, internet technology (Schrire & Levy, 2012), because he stated that three main goals of the best education systems (Fini, 2009) are (1) the best education systems can provide each individual who desires to learn and study in anytime and anywhere, (2) the best education system can offer the various platforms that person who want to share, can easily distribute over information and knowledge to person who want to learn, (3) the best education system can supply the person who want to set up and deliver issues and topics in regard to contemporary situation (Fournier, Kop, & Sitlia, 2011; Koutropoulos & Hogue, 2012). These connectivist educational conceptual goals have been a revolved origin of online-learning tendency. In the 1980s, a many classrooms of famous universities, such as New York University (NYU) are connected to a remote campus in order to provide closed-circuit video access for some out-of-campus students. Kop and Hill (2008) successfully applied new media venture methods to teach a seminar over the internet, using gopher and email, on the life and works of Street to the extensive out-of-campus students in the courses that open to all participants who could have access to radio and the internet, of the University of Pennsylvania (Jarrett, 2012). Siemens (2005) listed the essential eight principles of connectivist pedagogy theory (Kelland, 2006): (1) learning and knowledge rest in diversity of opinions, (2) learning is a process of connecting specialized nodes or information sources, (3) learning may reside in non-human appliances, (4) capacity to learn is more critical than what is currently known, (5) nurturing and maintaining connections is needed to facilitate learning, (6) ability to see connections between fields, ideas and concepts is a core skill, (7) accurate, up-to-date knowledge is the intent of all connectivist learning activities and (8) decision making is a learning process. Then, these principles was involved into MOOCs to from the connectivist MOOCs ("cMOOC") (Ravenscroft, 2011) and there are four brief course design of cMOOCs (Koutropoulos et al., 2012): (1) aggregation: cMOOCs courses enable to aggregate the numerous course's data and contents to be produced and disseminated in different online learning websites and then, integrate these information to be a complete newsletter or a comprehensive web page accessible to each participant because the traditional physical courses only can provide the prepared and fixed contents, (2) remixing: cMOOCs courses can easily associates diversified materials created within the course with each other and with other materials, (3) re-purposing purpose: cMOOCs enable to aggregate and remix course's materials to achieve the goals of each course's participant and (4) feedback: each participant enable to share re-purposed ideas with other global participants in cMOOCs.

Contiguously, Siemens (2005) also addressed the a series of the essential concepts into cMOOCs and these are concepts (Laurillard, 2007; Levin, 2013; Levy, 201; Mahraj, 2012; Roderick, 2008) are (1) diversity: the cMOOCs diversified comments from teachers' and students' are able to stimulate more knowledge and studying; (2) connecionization: the latest news, useful information and professional knowledge are easily able to connected in the online-learning procedures; (3) convenience: learning procedures are able to be operating without physical face-to-face platform; (4) continuousness: continuous learning is necessary for knowledge connection without time and space limitation; (5) recordability: learning history among different thinking, concepts and subjects of each participant are necessary recorded because these are core parts in cMOOCs and (6) openness: and the main goal of connectivist education theory is that each participant is freely able to obtain the most correct and latest knowledge in the diversified subjects in anytime and anywhere (Lane & McAndrew, 2010). Mackness, Mak, and Williams (2010) pointed

out that most acid tests for the first users of cMOOCs courses are shortage of interactions and autonomy study (Vardi, 2012; Vygotsky, 1978) due to the specific open and free characteristics of cMOOCs basic concepts. They further indicated that open character enable course's contents to be diversified; however, it also results in the participants are difficult to unsystematically study and discuss these scattered topics of these courses in cMOOCs (Vihavainen, Luukkainen, & Kurhila, 2012). Contiguously, Wiley (2003) pointed out internet technology can expand the "teacher bandwidth" by employing "technological bandwidth" because the number of students are capable of serving with our distance education offerings by internet technology (Wiley, Recker, & Gibbons, 2000) through the complete the learning objects (Weller, 2007). The learning objects is a kind of an instructional technology (Wiley, 2006) that can lead students for the position of technology of choice in the next generation of instructional design, development, and delivery, due to its potential for reusability, generativity, adaptability, and scalability. The concept of the learning objects has become the basic principle of the development of cMOOCs because cMOOCs depends on the four participant's elements, such as "posted resources", "self-studying management system", "learning Management System (LMS)" and "open internet resource" (Laroche, Nicol, & Mayer-Smith, 2007)., in order to provide the latest news, the useful information and the professional knowledge in the online learning courses. With speedy development of cMOOCs, Wiley and Hilton (2009) proposed the content-based MOOCs ("xMOOCs") from cMOOCs because he considered cMOOCs more focus on "creativity and dynamicity" and xMOOCs more emphasize on "behaviourist". Rodriguez (2012) further induced that cMOOCs applied connectivist approaches to develop the online learning courses and xMOOCs employed the behaviourist approaches to design courses content, according to his multiple case studies comparisons. In succession, Yuan, MacNeill, and Kraan (2008) refered that "xMOOCs now being developed by elite US institutions that follow a more behaviourist approach" (Tschofen & Mackness, 2012). Consequently the comparison of cMOOCs and xMOOCs are described in Table 3.

In succession, the four essential concepts of current MOOCs can be integrated from Table 3 and these are (1) "M" – massive participants: the numerous teachers, students and supporters, (2) "O" – open registration: course open content and materials and lowest costs for participants' afford, (3) "O" – online learning: real-time interaction among each extensive participant and (4) "C" – free-kind courses materials: self-paced requests, start/end period, college credits certificate, badges, role of the instructors, learning community and scripted assessments and course feedback (Mehlenbacher, 2012). On the other hand, potential advantages of MOOCs (Mak, Williams, & Mackness, 2010) are (1) learning is not necessary to be traditional physical classroom and full-length class syllabuses because learning is able to be happened in anytime and anywhere (Martin, 2012); (2) all educated, instituting and learning activities are based on free-surfing, free-sharing and free-criticizing of each online-learning participant (McAuley, Stewart, Siemens, & Cormier, 2010); (3) each online-learning participant is easily able to start to study through internet connection; there are a lot of various format of assignments in any online-learning

**Table 3.** Overview of Taiwanese MOOCs websites

Essential Concept	cMOOCs	xMOOCs
<b>Massive (M)</b>	Community and connections	Scalability of provision
<b>Open (O)</b>	Open access & license	Open access – Restricted license
<b>Online (O)</b>	Networked learning across multiple platforms and services	Individual learning in single platform
<b>Course (C)</b>	Develop shared practices, knowledge and understanding	Acquire a curriculum of knowledge & skills

Source: Rodriguez (2012) and Peters (2008)

subject that is completely different with the traditional physical classroom (Meyer, 2012); (4) the constructed costs of MOOCs are much lower than the traditional physical classroom resulted in MOOCs is able to provide the totally free courses; (5) each MOOCs participant is effortless to take courses without official registration; (6) each MOOCs participant is able to be teacher and student (Özdamar Keskin, & Metcalf, 2011); (7) language barrier is conquered by the free translation of each MOOCs participant; (8) MOOCs is easily to associated with any kind of institutes and organizations; (9) each MOOCs participant is definitely able to discuss the current issue and various topic in MOOCs and each MOOCs participant is comprehensively able to establish individual social-networking or personal online community (Masters, 2011). On the other hand, there are series disadvantages of MOOCs (Robbins, 2013; Stewart, 2010; Traxler, 2010): (1) the interactions between teachers and students may be a few because there is no passive stimulation of course's official registration request, (2) there is a lack of individual present opportunities and express empirical experience in MOOCs because of no face-to-face communication, (3) the academic fraudulent conducts of online examinations may be increase due to a lack of assessed effectively online-examination norms and supervised rules, (4) it is difficult to efficiently assess the online-learning consequences of numerous participated students as well as effectively offer the online learning study-resume file of each participated student to other higher education institutes and these students' recruiters and (5) the most serious issue of MOOCs is the lowest course completion rate because there is no official request in each MOOCs (Mehaffy, 2012)..

Furthermore, in the light of methodology in this research, this research not only employs QFD-HOQ model to cross-assess the questionnaire weights of three expert groups (MOOCs website plans, MOOCs Taiwanese college students and MOOCs scholars and researchers) to increase the research validity but also applies MCDM statistic method into the measurements of expert's questionnaire weights to strengthen the research reliability. Essentially, Akao (1997) innovatively create QFD-HOQ model to appraise each influenced element in product design process because QFD-HOQ model can effectively and instantaneously reflected highly changeable customers' desires on the design systematic procedures under limited resources and time in order to satisfy the exact needs of customers (Bevilacqua, Ciarapicab, & Giacchettab, 2006). Moreover, the foundational characteristics and definitions of each element in QFD-HOQ are described in the following points:

1. *Enterprises*: the analytical companies are described as the research analytical objective.
2. *Customers*: the customers are defined as presented as the research analytical objective.
3. *Customer needs (WHATs)*: the needs of customer are represented as the requirements and expectation of students by expressing their general languages and are constructively categorized hierarchies formality for efficiently comprehending and analyzing.
4. *Correlation matrix of customer needs*: the correlation matrix not only consists of the connection between pairwise of WHATs through comparing analysis and empirical experience but also offers the method to identify the decision-making niche key-point. The level of correlation is evaluated by Likert's scale evaluation with respect to the related interdependence and importance from equal important to extreme important.
5. *Related importance ratings of customer needs*: the related importance ratings of the WHATs are assessed by the customers with Likert's point scale evaluation as well.

6. *Sale-point*: the possibility of company's business position is presented as a sale-point. Usually, the important WHATs is rated "great" which, in turn, is defined as a "strong" sale-point, a "moderate" sale-point presents the importance ratings (or competitive opportunity) is still not so great, and no business opportunity are expressed as a "no" sale-point.

7. *Final Related importance ratings of customer needs (WHATs)*: the final importance ratings of WHATs are computed as

$$\text{Final related importance ratings of WHATs} = \sum (\text{relative importance} \times \text{ameliorating ratios} \times \text{sale-point})$$

8. *Competitors' assessment*: the related performance of the product competitors' assessment are evaluated by the customers from comparing products of company from competitor aspect and the measured scale are familiar on related importance ratings of the WHATs.

9. *Technical competitive assessment*: the assessment of competitors' techniques is to evaluate the performance of company's products by comparing competitors' familiar products, services or technologies through pairwise comparison of each HOW.

10. *Technical measurements (HOWs)*: the measurements of the corporate requirements for experts related with the specifications of products, services or technologies are definitely interrelated with the WHATs.

11. *Correlation matrix of technical measurements*: the correlation matrix not only consists of the relations between pairwise of the HOWs through comparing analysis and empirical experience but also provides the approach to identify the trend of product development in order to obtain enough competition to compete with competitors and the evaluated scale are the similar on correlation matrix of WHATs.

12. *Goals for customer needs*: the goals for customer needs are performed from practical customer need in order to meet what customers' desire and the assessed scale is similar with related importance ratings of the WHATs.

13. *Goals for technical measurements*: the goals for technical measurements are established to meet performance goals on each HOW in order to compete with competitors.

14. *Related importance ratings of technical measurements*: the related importance ratings of the corporate requirements for experts are evaluated by the customers and it is principle output of QFD-HOQ model. The measured equation function is usually expressed as

Related importance ratings of the HOWs

$$= \sum (\text{final importance rating of the WHATs} \times \text{relationship value between the WHATs and the HOWs})$$

15. *Ameliorating directions of the HOWs*: the customers' satisfaction is better able to be meeting through identify improving directions of HOWs after measuring the QFD model of the HOQ method and essentially, there are types of ameliorating directions: maximizing (or increasing) targets, meeting targets (or guidelines, standards and so on), minimizing (or decreasing) targets.

16. *Relationship matrix between each WHAT and HOW*: the pairwise matrix of relations between WHATs and HOWs is used to differentiate the correlated level between each WHAT and HOW and the measured scale is familiar with related importance ratings of the WHATs.

17. *Probability factors*: the probability factors are the factor to meet the performance goal for each HOW and generally through Likert's point scale evaluation.

As for the theoretical concept of QFD-HOQ, the interrelationship between the customer’s demands (WHATs) and corporate technological offers (WHOTs) are able to be systematically discussed as well as hierarchically assayed through the relationship matrix (WHATs vs. HOWs) and technological requirement matrix (HOWs vs. WHATs) in order to distinctly achieve the order of WHATs and HOWs (How Goal Matches). In succession, after the definition of the indispensable elements of QFD-HOQ model, the statistically evaluated measurements are completely constructed step-by-step in order to estimate the appraised matrices: the WHATs, related importance ratings of the WHATs, the HOWs, related importance ratings of the HOWs, and relationship matrix between the WHATs and the HOWs through the comparison of MCDM methodology. In order to obtain the exact the WHATs, the ANP is applied to classify the weights of the WHATs and the HOWs based on a series of comprehensive surveyed literatures. Besides, in order to concentrate on the relationship among the WHATs, the HOWs and goal of the WHATs and the HOWs, the two interrelation matrices of functional interactions of WHATs and HOWs are described in Figure 1. The **W1** indicates a vector which expresses the impact of the goal, which achieves the satisfaction of the WHATs. From the customer needs perspective, **W2** is the evaluated matrix that expresses the influence of the WHATs on each HOW. **W3** and **W4** individually present the assessed matrices of the internal dependence of the WHATs and HOWs. In order to avert the linguistic amphiboly of surveyed questionnaires, EM, FT and TOPSIS approaches of MCDM methodology are hierarchically cross-applied for strengthening research reliability.

Based on the fundamentally analytical integrity matrices of QFD-HOQ model in Figure 1, the main research steps are hierarchically and systematically constructed and described in Figure 2.

In the light of the fundamental application of QFD-HOQ model, it is to recognize the needs of customers for the empirical enterprise and then to identify the importance ratings through a customer survey (Hauser & Clausing, 1998). As for the qualitative and quantitative analysis and descriptions, QFD-HOQ model is hierarchically constructed step-by-step in the researches in order to discover the potentially impacted factors in diversified research fields. Significantly, this research further applies MCDM methodology to deal with the questionnaire-weight evaluations of three expert groups and MCDM methodology. As for the relative literatures of FT. Yoon and Hwang (1985) pioneered the fuzzy set theory to develop the fuzzy set and membership of the meaning for substituting the crisp set of traditional mathematics which can set up the uncertain and fuzzy research problems. Particularly, the fuzzy set covers two characteristics (membership degree and membership function) to solve the two-side (correct or incorrect) logical positivism issue of the traditional appraised mathematics (Zadeh, 1965). Based on the original concept of FT, the questionnaire weights are measured by the specific fuzzy set expressing a fuzzy concept “uncertain b” or “approximately b” which presents the Crisp Numbers (“CNs”) and Symmetrical Triangular Fuzzy Numbers

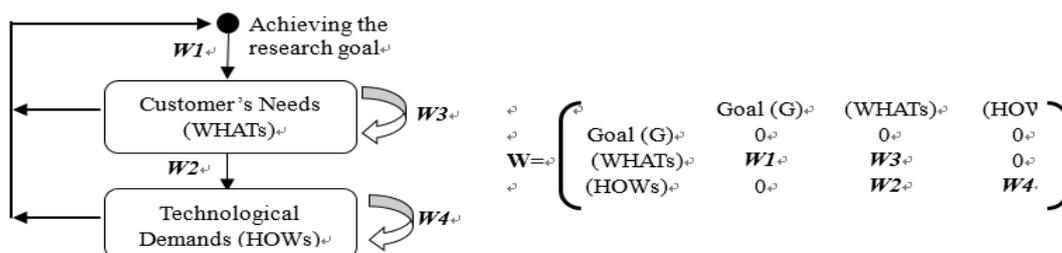
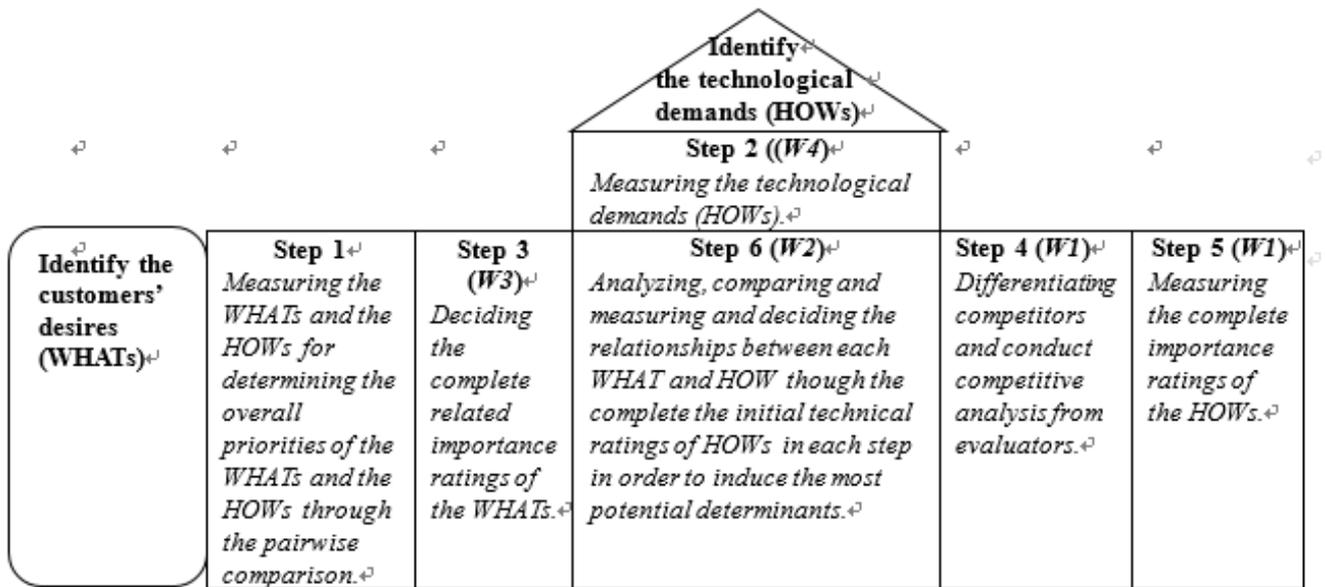


Figure 1. The analytical integrity matrix of QFD-HOQ



**Figure 2.** The 6-step measurements of QFD-HOQ model

(“STFNs”) , such as  $(STEN, CN, STEN) = (1, 2, 3)$  , for linguistic evaluation to improve questionnaire indefiniteness (Tsujimura, Park, Chang & Gen, 1993). Consequently, as to the defuzzified measurements, Tsujumura, Gen, and Kubota (1993) applied extension principle (Adamopoulos & Pappis, 1996) to estimate the fuzzy number of two triangle sharp and the assessed number of similarity measure (“S [A,B] ”) (Opricovic & Tzeng, 2003) is presented as

$$\begin{aligned}
 &A = (c_1, a_1, b_1) \text{ and } B = (c_2, a_2, b_2), \text{ and then,} \\
 &S [A,B] = \left( \begin{array}{l} 1, \text{ if } A=B \\ \exp. \left( -(d_{LR}^2[A, B] / \sigma) \right), \text{ if } A \neq B \end{array} \right) \\
 &d_{LR}^2[A, B] = (a_1 - a_2)^2 + [(c_1 + a_1) - (c_2 + a_2)]^2 / 4 + [(b_1 - a_1) - (b_2 + a_2)]^2 / 4 ; \\
 &\sigma = (D^* + D_*) / 2 + (|c_1 - c_2| + |b_1 - b_2|) / 8 ; \\
 &D^* = |(a_1 + b_1) - (a_2 + b_2)| / 2 ; D_* = |(a_1 + c_1) - (a_2 + c_2)| / 2 \tag{1}
 \end{aligned}$$

Further, in order to more effectively and efficiently resolve issues with uncertainty and limitation, Chen, Lin, and Lee, (2004) invented the Grey System Theory (“GST”) to form the GRA approach deal with the level of relation between each assessable criteria for achieving the research purposes of managerial control, decision-making, and foreseeing under the patterns of uncertain research problems or circumstances (Deng, 1982). GST firstly transfer all research data to be located between 1 (white system) and 0 (black system) to calculate the trend-level among uncertain and incomplete information of each assessable criterion to quantify the level of relation in order to assess the dependence or independence relations between each assessable criterion in the equation (2), (3) and (4) of GRA approach as illustrated as If the analytical goal belongs efficient goal and satisfies the maximized analytical goal (the larger the better, LTB) and the equation are described as

$$X_i^* = (X_i^{(0)}(k) - \text{Min}X_i^{(0)}(k)) / (\text{Max}X_i^{(0)}(k) - \text{Min}X_i^{(0)}(k)) \tag{2}$$

If the analytical goal belongs cost goal and satisfies the minimized analytical goal (the smaller the better, STB) and the equation are presented as

$$X_i^* = (\text{Min}X_i^{(0)}(k) - X_i^{(0)}(k)) / (\text{Max}X_i^{(0)}(k) - \text{Min}X_i^{(0)}(k)) \tag{3}$$

If the analytical goal belongs specific goal (nominal the best) and the GST equation are expressed as

$$X_i^* = 1 - \left( |X_i^{(0)}(k) - OB| / \text{Max} \{ (MaxX_i^{(0)}(k) - OB, OB - MinX_i^{(0)}(k)) \} \right) \quad (4)$$

In the above equations, the  $X_i^*$  represents comprehensive grey weights,  $MinX_i^{(0)}(k)$  expresses the minimum of original data and  $MaxX_i^{(0)}(k)$  is the maximum of original data (Deng, 1989; Deng, 1993). Momentously, in order to increase the science, accuracy, manoeuvrability of MCDM method, most social science researchers have commenced to employ TOPSIS approach in the decisive-making evaluations, such as land usage, manufacture material selection, finance investment assessments, health medicine and hygiene investigation and etc. (Deng, 2005) because TOPSIS is able to not only synthetically measure but also comprehensively discuss the relative distances and influences among the each evaluated criterion, sub-criterion and solution (alternative scheme or decision). As to the brief and preliminary concept and assumption in TOPSIS approach, Shih, Lin and Lee (2001) addressed that the ideal solution is the Positive Ideal Solution ("PIS", 1 (1,1,1)) and the Negative Ideal Solution ("NIS", 0 (0,0,0)) (Shyura & Shih, 2006) because the selected solution is not only the shortest distance from PIS but it is also the longest distance from NIS simultaneously. In viewing TOPSIS mathematics, the research goals and evaluated criteria are supposed to be discussed by the experts because the weights of each selected goal and evaluated criterion are completely appraised through the consequences of their comments and questionnaires generated the mathematic goal-decision-weight matrix in order to optimize the evaluation among each selected goal and evaluated criterion. Then, Shih (2008) considered that the calculations of selected alternative are supposed to cover the shortest distance from the Fuzzy Positive Ideal Reference Point ("FPIRP",  $A^+$ ) as well as the longest distance from the Fuzzy Negative Ideal Reference Point ("FNIRP",  $A^-$ ) for resolving series of relative problems in the MCDM fields (Shih, Shyurb, & Lee, 2007). Consequently, the equations of PIS and NIS are individually demonstrated as

$$d_i^+ = \sum_{k=1}^n d(V_{ij}, V_j^+) = \sqrt{((a_1 - 1)^2 + (b_1 - 1)^2 + (c_1 - 1)^2) / 3}, \quad i = 1, \dots, m ; \quad i = 1, \dots, n,$$

$$V_j^+ = (1, 1, 1)$$

$$d_i^- = \sum_{k=1}^n d(V_{ij}, V_j^-) = \sqrt{((a_1 - 0)^2 + (b_1 - 0)^2 + (c_1 - 0)^2) / 3}, \quad i = 1, \dots, m ; \quad i = 1, \dots, n,$$

$$V_j^- = (0, 0, 0)$$

$$CC_m(V1, V2) = d_j^- / d_j^+, \text{ where } CC_m(V1, V2) \text{ presents the evaluated weights of TOPSIS} \quad (5)$$

## EMPIRICAL MEASUREMENTS

Significantly, the 6-steps analytical processes are hierarchically related with QFD-HOQ model as demonstrated in figure 2 and the empirical measurements are systematically associated with the statistic equations of MCDM method.

### First Step - Identifying each WHAT in order to determine the overall priorities of WHATs and HOWs through the comparison of pairwise matrices

This first step research is to identify the students' online learning interests ("WHATs") in Taiwanese higher education. According to the related literatures,

there are the sixteen students' online learning interests (WHATs) can be refined in the four categories: Course Operation ( $^{WHAT_{CO}}$ ): (1) convenience ( $^{W_1}$ ), (2) connectionization ( $^{W_2}$ ), (3) recordability ( $^{W_3}$ ), (4) completely unrestricted operation ( $^{W_4}$ ); Course Content ( $^{WHAT_{CC}}$ ): (5) openness ( $^{W_5}$ ), (6) diversity ( $^{W_6}$ ), (7) continuousness ( $^{W_7}$ ), (8) open internet resource ( $^{W_8}$ ); Course Assessment ( $^{WHAT_{CA}}$ ): (9) peer-review ( $^{W_9}$ ), (10) course complete rate ( $^{W_{10}}$ ), (11) learning Management System (LMS) ( $^{W_{11}}$ ), (12) self-studying management system ( $^{W_{12}}$ ) and Course Services ( $^{WHAT_{CES}}$ ): (13) professionalization ( $^{W_{13}}$ ), (14) automated feedback ( $^{W_{14}}$ ), (15) group collaboration ( $^{W_{15}}$ ) and (16) freely educational resources ( $^{W_{16}}$ ). Subsequently, in order to fully refine the assessable weights of each WHAT, GRA approach is employed to appraise the questionnaire results from thirty random fourth-year senior college students representing four Taiwanese universities with reference to the equation (2), (3) and (4). Due to the two kinds of the Taiwanese senior high schools, including general education school and vocational school. Therefore, in order to reinforce the research reliability and representativeness, these interviewed college students covered four major conditions of college students: (1) education academic background with the graduation from general education school: 5 from the Department of Education at the National Taichung University of Education ( $^{C_A}$ ); education academic background with the graduation from vocational school: 5 from the Department of Education at the National Taichung University of Education ( $^{C_A}$ ); (2) IT academic background with the graduation from general education school: 5 from the Department of Computer Science and Engineering at National Chung-Hsing University ( $^{C_B}$ ); IT academic background with the graduation from vocational school: 5 from the Department of Computer Science at National Chin-Yi University of Technology ( $^{C_C}$ ) and no educational and IT academic background with the graduation from general education school: 5 from the Department of Business Administration at Ling Tung University ( $^{C_D}$ ); no educational and IT academic background with the graduation from vocational school: 5 from the Department of Business Administration at Ling Tung University ( $^{C_D}$ ). The description statistics of these thirty interviewed college students are expressed in Table 4.

Consequently, after calculating the grey relation coefficients of each WHAT, the surveyed weights of the WHATs are measured as  $^{WHAT_{CO}} = 0.341$ ,  $^{WHAT_{CC}} = 0.267$ ,  $^{WHAT_{CA}} = 0.224$  and  $^{WHAT_{CS}} = 0.168$ .

**Table 4.** Background of the thirty college students interviewed

Questionnaire Items	Questionnaire statistic description
<b>Gender</b>	Male: 53.33 % (16) Female: 46.67 % (14)
<b>Usage experienced years in the relative MOOC fields</b>	0-1 year: 40% (12) More than 1 year: 60 % (18)
<b>Graduation Condition</b>	senior high schools: 50% (15) vocational schools: 50% (15)
<b>Professional Characteristics</b>	Education academic Background: 33.33 % (10) IT academic Background: 33.33 % (10) Business academic Background: 33.34 % (10)

**Second Step - Identifying each HOWs in order to determine the overall priorities of the WHATs and the HOWs through the comparison of pairwise matrices**

This second step is to identify the MOOCs online learning measures (HOWs) in Taiwanese higher education. According to the related literatures, there are the sixteen technological online-education measures (HOWs) to be refined to four categories: Basic Function (“ $HOW_{BF}$ ”): (1) aggregation technology function (“ $H_1$ ”), (2) remixing technology function (“ $H_2$ ”), (3) re-purposing technology function (“ $H_3$ ”), (4) feedback technology function (“ $H_4$ ”); Course Function (“ $HOW_{CF}$ ”): (5) course professionalization technology function (“ $H_5$ ”), (6) course evaluation technology function (“ $H_6$ ”), (7) course certification technology function (“ $H_7$ ”), (8) courses promotion technology function (“ $H_8$ ”); Operation Function (“ $HOW_{OF}$ ”): (9) word and video communication technology function (“ $H_9$ ”), (10) digital-folder record technology function (“ $H_{10}$ ”), (11) course encyclopedia technology function (“ $H_{11}$ ”), (12) compatibility technology function (“ $H_{12}$ ”) and Service Function (“ $HOW_{SF}$ ”): (13) study-resume technology function (“ $H_{13}$ ”), (14) job-match technology function (“ $H_{14}$ ”), (15) feedback technology function (“ $H_{15}$ ”), and (16) social-networking technology function (“ $H_{16}$ ”). Contiguously, in order to fully refine the appraised weights of each HOW, the equation (2), (3) and (4) of GRA approach is applied to appraise the questionnaire results of the thirty fourth-year senior college students ( $C_A, C_B, C_C$  and  $C_D$ ). As a result, after comparing the grey relation coefficients of each HOW, the surveyed weights of the WHATs are  $HOW_{BF} = 0.271$ ;  $HOW_{CF} = 0.192$   $HOW_{OF} = 0.254$  and  $HOW_{SF} = 0.283$ .

**Third Step - Deciding the complete related importance ratings of the WHATs (W1 matrix)**

In order to fully analyze the extent of students’ requests and wants with higher research reliability, this research collected the compare-matrix questionnaire-weights of five online learning researchers who have focused on online learning students’ behaviors in a long period of time. Background information of these researcher interviewees are expressed in Table 5.

On the other hand, as for the higher research validity, the hierarchical measurements of FT is applied in the statistic calculations of the 9-point Likert’s scale of the complete related importance ratings of WHATs as described in Table 6 and specifically, the original surveyed weights of interviewed questionnaire are expressed in Table 6.

**Table 5.** Background information on the five researchers interviewed

Questionnaire Items	Questionnaire statistic description
Gender	Male: 60 % (3) Female: 40 % (2)
Researching experienced years in the relative MOOC fields	0-3 years: 40 % (2) Over 3 years: 60 % (3)
Education	Master degree: 20 % (1) Doctoral degree: 80 % (4)
Professional Characteristics	Education academic Background: 20 % (1) IT academic Background: 80 % (4)

**Table 6.** The related importance ratings of WHATs

	Research 1		Research 2		Research 3		Research 4		Research 5		Related important ratings	
	GN	STEN	GN	STEN								
(0.341)	6	[5,7]	6	[5,7]	7	[6,8]	7	[6,8]	6	[5,7]	2.1824	[1.8414, 2.5234]
	5	[6,7]	5	[4,6]	5	[4,6]	7	[6,8]	5	[4,6]	1.8414	[1.5004, 2.1824]
	6	[5,7]	6	[5,8]	6	[5,7]	6	[5,7]	4	[3,5]	1.9096	[1.5686, 2.2506]
(0.267)	6	[5,7]	7	[6,8]	6	[5,7]	8	[7,9]	7	[6,8]	2.3188	[1.9778, 2.6598]
	5	[4,6]	6	[5,7]	6	[5,7]	5	[4,6]	6	[5,7]	1.4952	[1.2282, 1.7622]
	5	[4,6]	6	[5,7]	5	[4,6]	6	[5,7]	8	[7,9]	1.602	[1.335, 1.869]
	3	[2,4]	5	[4,6]	6	[5,7]	4	[3,5]	5	[4,6]	1.2282	[0.9612, 1.4952]
(0.224)	3	[2,4]	4	[3,5]	8	[7,9]	6	[5,7]	7	[6,8]	1.4952	[1.2282, 1.7622]
	7	[6,8]	4	[3,5]	7	[6,8]	4	[3,4]	5	[4,6]	1.2096	[0.9856, 1.4336]
	5	[4,6]	6	[5,7]	6	[5,7]	7	[6,8]	6	[5,7]	1.344	[1.12, 1.568]
	4	[3,4]	6	[5,7]	8	[7,9]	8	[7,9]	5	[4,6]	1.3888	[1.1648, 1.6128]
(0.168)	8	[7,9]	4	[3,5]	7	[6,8]	6	[5,7]	7	[6,8]	1.4336	[1.2096, 1.6576]
	5	[4,6]	5	[4,6]	6	[5,7]	6	[5,7]	7	[6,8]	0.9744	[0.8064, 1.1424]
	7	[6,8]	5	[4,6]	6	[5,7]	5	[4,6]	4	[3,5]	0.9072	[0.7392, 1.0752]
	5	[4,6]	7	[6,8]	7	[6,8]	6	[5,7]	7	[6,8]	1.0752	[0.9072, 1.2432]
	7	[6,8]	5	[4,6]	6	[5,7]	7	[6,8]	5	[4,6]	1.008	[0.84, 1.176]

**Fourth Step - Differentiating competitors and conduct competitive analysis from evaluators (W1 matrix)**

In order to increase the representativeness, the competitive analysis of the HOWs is conducted in this session to recognize each HOW and in particular, these selected companies are the current four Taiwanese universities ( $C_A, C_B, C_C$  and  $C_D$ ). Furthermore, as for the measurement of the “probability distribution”, entropy method is applied for calculating the entropy method number ( $EM(H_m)$ ) because entropy method is definitely able to handle the amount of uncertain and various databases by discrete probability distribution ( $EM(H_1, H_2, \dots, H_m)$ ) and the

$$EM(H_1, H_2, \dots, H_m) = -\varnothing_L \sum_{i=1}^L P_i \ln(p_i)$$

equation of the entropy method is described as  
 where  $\varnothing_L = 1 / \ln(L)$  means a normalization constant to make sure  $0 \leq E(H_1, H_2, \dots, H_m) \leq 1$  (6)

For the row of  $m$  the comparison matrix  $X$  from scholars corresponding to the HOWs  $D_m$ , the total score with reference to  $EM(H_1, H_2, \dots, H_m)$  can computed as  $X_m = \sum_{i=1}^L X_m$ ;  $X = (X_1, X_2, \dots, X_m)$ . In order to truly discover technological function evaluation of four MOOCs websites ( $M_1, M_2, M_3$  and  $M_4$ ) of HOWs, entropy method is employed in the assessable measurements of the “probability distribution” of the  $EM(H_1, H_2, \dots, H_m)$  as

$$EM(H_1, H_2, \dots, H_m) = EM(HOWs_m) = -\varnothing_L \sum_{i=1}^L P_{mL} \ln(p_{mL}) = -\varnothing_L \sum_{i=1}^L (X_{mL} / X_m) \ln(X_{mL} / X_m) \quad (7)$$

Moreover, after the assumed consideration in competitive analysis, the appraised weights of goals are 8 in each HOW. Consequently, as for the higher research validity, the conceptual measurements of fuzzy theory is further employed in the statistic measurements of the 9-point Liker’s scale of the improvement ratings for WHATs ( $IR_x; X = (X_1, X_2, \dots, X_m)$ ) as calculated as  $IR_x = Gaol_{HOWs} / AverageX_{HOWs}$ .

As a result, the improvement ratings of  $H_1$  is measured as  $IR_{H_1} = 8 / (5 + 5 + 7 + 8 + 8) / 5 = 1.21$  and the others’ improvement ratings are

presented in Table 3. Consequently, based on the equation (6) and (7), entropy complete related importance ratings of the HOWs of  $H_1(EM(HOW_{s,m}))$  is calculated as

$$EM(H_1)_{GM} = \sum_{l=1}^1 P_{H_1} \ln(p_{H_1}) = -\sum_{l=1}^1 (X_l/X_1) \ln(X_l / X_1)$$

$$= -[((0.2797 * \ln(0.2797)) + ((0.264 * \ln(0.264)) + ((0.2549 * \ln(0.2549)) + ((0.2288 * \ln(0.2288)))] = 0.0637$$

Consequently, the entropy complete related importance ratings of the others' HOWs are as shown in Table 7 and specifically, the original surveyed weights of interviewed questionnaire are also expressed in Table 7.

**Fifth Step - Measuring the complete importance ratings of HOWs (W1 matrix)**

With reflect to the measured results of the improvements ratings of each HOW under the competitive analysis of entropy method from first step to fourth step, the complete importance ratings of HOWs in the CN ( $CIM(HOW_s)_{CM}$ ) are compute as  $CIM(HOW_{s,VIS,VCS,VDS,VTS})_{GM} = (HOW_{VIS,VCS,VDS,VTS} \times W1 \times W2)$ . Specifically, the application of entropy methods, similar measure and TOPSIS are utilized in this study to minimize the indistinctness of the linguistic exactitude and to decreasing the subjective concepts of the five selected customers. As a result, the complete

importance ratings of HOWs of  $H_1(CIM(H_1)_{CM})$  in the CN is calculated as

$$CIM(HOW_{s,VIS,VCS,VDS,VTS})_{CM} = (HOW_{VIS,VCS,VDS,VTS} \times W1 \times W2) = 2.1824 * 1.2121 * 0.0637 = 0.2017$$

Therefore, the total complete importance ratings of HOWs in the GN are measured and described as

**Table 7.** Improvements ratings of each HOW under the competitive analysis of entropy method

	Scholar 1				Scholar 2				Scholar 3				Scholar 4				Scholar 5				Competitive Analysis				Goa Is	IR <sub>x</sub>	EM(HOW <sub>s,m</sub> )
	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>			
H <sub>1</sub>	5	7	7	6	5	7	6	5	7	8	4	3	8	7	5	7	8	4	3	6	6.6	6.6	5	5.4	8	1.2121	0.0637
H <sub>2</sub>	7	4	6	8	8	7	5	6	6	6	7	5	6	8	6	7	6	7	5	4	6.6	6.4	5.8	6	8	1.2121	0.0638
H <sub>3</sub>	4	6	4	5	7	6	4	5	8	8	5	2	4	3	3	5	8	5	2	5	6.2	5.6	3.6	4.4	8	1.2903	0.0629
H <sub>4</sub>	2	5	5	5	4	3	3	6	6	7	6	4	4	6	5	7	7	6	4	5	4.6	5.4	4.6	5.4	8	1.7391	0.0626
H <sub>5</sub>	5	4	5	4	4	6	5	3	7	6	6	6	3	5	4	3	5	7	8	7	4.8	5.6	5.6	4.6	8	1.6667	0.0627
H <sub>6</sub>	4	3	3	4	3	5	4	5	5	5	4	7	4	4	5	5	4	3	5	6	4	4	4.2	5.4	8	2	0.0614
H <sub>7</sub>	4	6	5	6	4	4	5	3	5	4	3	3	5	8	3	2	4	6	7	7	4.4	5.6	4.6	4.2	8	1.8182	0.0625
H <sub>8</sub>	3	5	4	4	5	8	3	5	6	4	6	5	4	4	2	4	8	4	3	6	5.2	5	3.6	4.8	8	1.5385	0.0626
H <sub>9</sub>	4	4	5	3	4	4	2	7	8	3	5	4	6	7	4	4	6	7	5	3	5.6	5	4.2	4.2	8	1.4286	0.0628
H <sub>10</sub>	5	8	3	6	6	7	4	3	4	4	4	5	7	6	3	5	8	5	2	4	6	6	3.2	4.6	8	1.3333	0.0626
H <sub>11</sub>	4	4	2	3	7	6	7	5	5	5	8	3	8	5	4	3	7	6	2	6	6.2	5.2	4.6	4	8	1.2903	0.0629
H <sub>12</sub>	6	7	4	5	7	8	5	2	7	4	4	2	7	7	3	5	5	6	4	2	6.4	6.4	4	3.2	8	1.25	0.0623
H <sub>13</sub>	7	8	6	4	8	7	6	4	6	6	7	4	6	6	2	6	6	8	2	3	6.6	7	4.6	4.2	8	1.2121	0.0632
H <sub>14</sub>	6	8	4	3	6	6	5	4	5	7	5	5	7	6	4	2	5	6	7	5	5.8	6.6	5	3.8	8	1.3793	0.0629
H <sub>15</sub>	6	9	5	4	8	55	6	5	7	7	6	3	7	8	2	3	6	8	5	2	6.8	17.4	4.8	3.4	8	1.1765	0.0576
H <sub>16</sub>	7	8	6	4	8	8	7	6	5	6	5	5	7	6	5	4	7	7	6	4	6.8	7	5.8	4.6	8	1.1765	0.0635

$$CIM(H_1, \dots, H_{16})_{CM} = \begin{pmatrix} 0.1686, 0.1424, 0.1549, 0.2525, 0.1563, 0.1966, 0.1396, 0.1439, \\ 0.1086, 0.1122, 0.1128, 0.1116, 0.0747, 0.0787, 0.0729, 0.0753 \end{pmatrix}$$

Then, the complete importance ratings of the HOWs of  $H_1(CIM(H_1)_{GM})$  in the STEN is measured as  $CIM(H_1)_{STEN} = W1_{STEN} \times W2 \times W3 = [1.8414, 2.5234] * 1.2121 * 0.0637 = [0.1423, 0.195]$ . In succession, the total complete importance ratings of HOWs in STEN are calculated as

$$CIM(H_1, \dots, H_{16})_{STEN} = \begin{pmatrix} [0.1423, 0.195], [0.1160, 0.1688], [0.1272, 0.1825], [0.2154, 0.2897], \\ [0.1284, 0.1842], [0.1638, 0.2293], [0.1092, 0.1699], [0.1182, 0.1696], \\ [0.0885, 0.1287], [0.0935, 0.1309], [0.0946, 0.131], [0.0942, 0.1291], \\ [0.0618, 0.0875], [0.0641, 0.0932], [0.0615, 0.0843], [0.0627, 0.0878] \end{pmatrix}$$

Furthermore, in defuzzified consideration with the assumption of  $A_1 = (c_1, a_1, b_1) = (1, 1, 1)$  and  $A_2 = (c_2, a_2, b_2) = (0.1423, 0.1686, 0.195)$ , the final related importance ratings of HOWs of  $H_1(Fuzzy(FRIM(H_1)_{GM}) = Fuzzy(H_1(S[A, B])))$  in the STEN, based on the equation (1), is calculated as the following measurements:

$$D^* = |(a_1 + b_1) - (a_2 + b_2)| / 2 = 0.8446; \quad D_* = |(a_1 + c_1) - (a_2 + c_2)| / 2 = 0.8182;$$

$$\alpha = (D^* + D_*) / 2 + (|c_1 - c_2| + |b_1 - b_2|) / 8 = 1.7898$$

$$d^2(A_1, A_2) = (a_1 - a_2)^2 = [((c_1 + a_1) - (c_2 + a_2))^2 / 4] + [((b_1 + a_1) - (b_2 + a_2))^2 / 4] = 2.074$$

$$Fuzzy(FRIM(H_1)_{STEN}) = Fuzzy(S[A, B]) = \exp. (-d^2 / \alpha) = 1.1588, \text{ if } V_1 \neq V_2$$

Further, the total final related importance ratings of HOWs in the STENs is calculated and described as

$$Fuzzy(FRIM(H_1, \dots, H_{16})_{STEN}) = (0.863, 0.8363, 0.8493, 0.9666, 0.8508, 0.8962, 0.835, 0.8375, 0.8019, 0.8047, 0.805, 0.8037, 0.7699, 0.7738, 0.7679, 0.7702)$$

As a result, the rank of the final related importance ratings of the HOWs in the below order:

$$FEIM(S[A, B]): H_4 \succ H_6 \succ H_1 \succ H_5 \succ H_3 \succ H_8 \succ H_2 \succ H_7 \succ H_{11} \succ H_{10} \succ H_{12} \succ H_9 \succ H_{14} \succ H_{16} \succ H_{13} \succ H_{15}$$

Subsequently, in order to increase the research validity, TOPSIS approach is further utilized into the QFD-HOQ and based on the equation (5), the final related

importance ratings of the HOWs of  $H_1(FEIM(CC_{H_1}(V_1, V_2)))$  in TOPSIS is calculated as

$$H_1(d_i^+) = \sqrt{[(a_1 - 1)^2 + (b_1 - 1)^2 + (c_1 - 1)^2] / 3} = 0.8317, \text{ where } V_1 = (0.1423, 0.1686, 0.195), V_2 = (1, 1, 1)$$

$$H_1(d_1^-) = \sqrt{[(a_1 - 0)^2 + (b_1 - 0)^2 + (c_1 - 0)^2]} / 3 = 0.1488$$

where

$$V_1 = (0.1423, 0.1686, 0.195), V_2 = (0, 0, 0)$$

$$(CC_{H_1}(V_1, V_2)) = H_1(d_i^-) / (H_1(d_i^+) + H_1(d_i^-)) = 0.1518$$

Furthermore, the total final related importance ratings of the HOWs ( $FEIM(CC_{H_1, \dots, H_{16}}(V_1, V_2))$ ) in STEN are calculated and described as

$$FEIM(CC_{H_1, \dots, H_{16}}(V_1, V_2)) = (0.1518, 0.1294, 0.1405, 0.2287, 0.1418, 0.1783, 0.1285, 0.1304, 0.0983, 0.1008, 0.1011, 0.0998, 0.067, 0.071, 0.0649, 0.0673)$$

Consequently, the rank of the final related importance ratings of the HOWs in the below order:

$$FEIM(CC(TOPSIS)): H_4 \succ H_6 \succ H_1 \succ H_5 \succ H_3 \succ H_8 \succ H_2 \succ H_7 \succ H_{11} \succ H_{10} \succ H_{12} \succ H_9 \succ H_{14} \succ H_{16} \succ H_{13} \succ H_{15}$$

As a result of fuzzy theory and TOPSIS approaches, feedback technology function ( $H_4$ ) of Basic Function ( $HOW_{BF}$ ), course evaluation technology function ( $H_6$ ) of Course Function ( $HOW_{CF}$ ), aggregation technology function ( $H_1$ ) of Basic Function ( $HOW_{BF}$ ), course professionalization technology function ( $H_5$ ) of Course Function ( $HOW_{CF}$ ) and re-purposing technology function ( $H_3$ ) of Basic Function ( $HOW_{BF}$ ) are the top five critical MOOCs online learning measures.

**Sixth Step - Analyzing, comparing and measuring and deciding the relationships between each WHAT and each HOW and complete the initial technical ratings of HOWs (W2 matrix)**

As for the increment of research representativeness, the questionnaire-weights data of comparing and measuring and deciding the relationships between each WHAT and each HOW are collected from five online learning industrialists who have over ten years working experience in the Taiwanese five MOOCs websites: III Proera, Homogeneous Educational Platform (HEP), NTHU sharecourse, NCTU ewant and U Taiwan LIFE. Then, the competitive analyses of the relationships between each WHAT and each HOW in the CN through the complete the initial technical ratings of HOWs are conducted in this step. FT approach was applied to measure the relationship competitive weights ( $In(H_m)$ ) of the competitive analyses of the relationships between each WHAT and HOW through the complete the initial technical ratings of HOWs and according to the equation (6) and (7), the total relationship competitive weights ( $In(H_1, \dots, H_{16})$ ) in the GN are calculated as

$$In(H_1, \dots, H_{16}) = (0.2465, 0.2088, 0.2842, 0.2439, 0.2062, 0.2465, 0.2088, 0.2842, 0.2439, 0.2062, 0.2816, 0.2421, 0.2199, 0.1822, 0.2576, 0.215)$$

Then, based on the equation (6) and (7), the total the competitive weights of the HOWs in the STEN are calculated and presented as

$$\begin{aligned}
 & \text{In}(H_1, \dots, H_{16})_{STEN} \\
 & = \left( \begin{array}{l} \mathbf{[0.2088, 0.2842]}, \mathbf{[0.2062, 0.2816]}, \mathbf{[0.2044, 0.2798]}, \mathbf{[0.2211, 0.2965]}, \\ \mathbf{[0.203, 0.2784]}, \mathbf{[0.1939, 0.2693]}, \mathbf{[0.1729, 0.2483]}, \mathbf{[0.1846, 0.2599]}, \\ \mathbf{[0.19, 0.2654]}, \mathbf{[0.1959, 0.2713]}, \mathbf{[0.1933, 0.2687]}, \mathbf{[0.1736, 0.249]}, \\ \mathbf{[0.1822, 0.2576]}, \mathbf{[0.1773, 0.2527]}, \mathbf{[0.1548, 0.2302]}, \mathbf{[0.1559, 0.2313]} \end{array} \right)
 \end{aligned}$$

Furthermore, in defuzzified consideration with the assumption of  $A_1 = (c_1, a_1, b_1) = (1, 1, 1)$  and  $A_2 = (c_2, a_2, b_2) = (0.2088, 0.2465, 0.2842)$ , based on the equation (1) of fuzzy theory approach, the relationship competitive weights of  $H_1(\text{Fuzzy}(\text{In}(H_1, \dots, H_{16})_{STEN}) = \text{Fuzzy}(H_1(\text{In}(S[A, B])))$  in the STEN were calculated as  $D^* = |(a_1 + b_1) - (a_2 + b_2)| / 2 = 0.7724$ ;

$$D_* = |(a_1 + c_1) - (a_2 + c_2)| / 2 = 0.7347$$

$$\alpha = (D^* + D_*) / 2 + (|c_1 - c_2| + |b_1 - b_2|) / 8 = 1.6342;$$

$$d^2(A_1, A_2) = (a_1 - a_2)^2 = [((c_1 + a_1) - (c_2 + a_2))^2 / 4] + [((b_1 + a_1) - (b_2 + a_2))^2 / 4] = 0.5397$$

$$\text{Fuzzy}(\text{In}(H_1)_{STEN}) = \text{Fuzzy}(S[A, B]) = \exp. (-d^2 / \alpha) = 0.3438, \text{ if } V_1 \neq V_2$$

Further, the total final related importance ratings of the HOWs in the STEN is calculated and described as

$$\begin{aligned}
 & \text{Fuzzy}(\text{In}(H_1, \dots, H_{16})_{STEN}) \\
 & = (0.3438, 0.3424, 0.3375, 0.3506, 0.3407, 0.3359, 0.3253, 0.3311, \\
 & \quad 0.3338, 0.3369, 0.3356, 0.3256, 0.3299, 0.3274, 0.3165, 0.317)
 \end{aligned}$$

Consequently, the rank of the final related importance ratings of WHATs in the below order:

$$\text{In}(S[A, B]): W_4 \succ W_1 \succ W_2 \succ W_5 \succ W_{10} \succ W_3 \succ W_6 \succ W_{11} \succ W_9 \succ W_8 \succ W_{13} \succ W_{14} \succ W_{12} \succ W_7 \succ W_{16} \succ W_{15}$$

Significantly, as for the addition of research validity, TOPSIS approach was further employed to measure the relationship competitive weights of the HOWs of

$$H_1(\text{In}(CC_{H_1}(V_1, V_2))) \text{ as}$$

$$H_1(d_i^+) = \sqrt{[(a_1 - 1)^2 + (b_1 - 1)^2 + (c_1 - 1)^2]} / 3 = 0.7541, \quad \text{where}$$

$$V_1 = (0.2088, 0.2465, 0.2842), V_2 = (1, 1, 1)$$

$$H_1(d_i^-) = \sqrt{[(a_1 - 0)^2 + (b_1 - 0)^2 + (c_1 - 0)^2]} / 3 = 0.2172, \quad \text{where}$$

$$V_1 = (0.2088, 0.2465, 0.2842), V_2 = (0, 0, 0)$$

$$(CC_{H_1}(V_1, V_2)) = H_1(d_i^-) / (H_1(d_i^+) + H_1(d_i^-)) = 0.2205$$

Consequently, the total relationship competitive weights ( $\text{In}(CC_{H_1, \dots, H_{16}}(V_1, V_2))$ ) of HOWs in the STEN is calculated and described as

$$\begin{aligned}
 & \text{In}(CC_{H_1, \dots, H_{16}}(V_1, V_2)) \\
 & = (0.2236, 0.2213, 0.211, 0.2344, 0.2185, 0.2105, 0.1922, 0.2023, \\
 & \quad 0.2071, 0.2123, 0.21, 0.1928, 0.2003, 0.196, 0.1765, 0.1775)
 \end{aligned}$$

Eventually, the total relationship competitive weights of the HOWs in the below order:

$lm(TOPSIS): W_4 \succ W_1 \succ W_2 \succ W_5 \succ W_{10} \succ W_3 \succ W_6 \succ W_{11} \succ W_9 \succ W_8 \succ W_{13} \succ W_{14} \succ W_{12} \succ W_7 \succ W_{16}$

As a result of fuzzy theory and TOPSIS approach, the User completely unrestricted operation ( $w_4$ ) of Course Operation ( $WHAT_{CO}$ ), convenience ( $w_1$ ) of Course Operation ( $WHAT_{CO}$ ), connectionization ( $w_2$ ) of Course Operation ( $WHAT_{CO}$ ), openness ( $w_5$ ) of Course Content ( $WHAT_{CC}$ ) and course complete rate ( $w_{10}$ ) of Course Assessment ( $WHAT_{CA}$ ) are also the five most critical students' online learning interests (WHATs).

## CONCLUSIONS

In this high-speed digitalization era, online learning MOOCs has played a significant role in the majority of students' studying behaviors, especially those in Taiwanese college; especially, the development of Taiwanese MOOCs websites is at this moment full of vitality. For this reason, this research not only employs the analytical cross-measurements of the QFD-HOQ model and MCDM methodology for the increment of research validity but it also applies the cross-evaluations of weighted results from a questionnaire based on three major analytical perspectives (higher education student's desires, online-learning technological functions and online-education scholar's considerations). These cross-evaluations also provided additional research reliability to assess the independences and relationships between students' online-learning interests (WHATs) and the technological online-education measures (HOWs) in order to synthetically explore the most critical technological determinants of MOOCs website in the Taiwanese higher education sector. Beyond a series of complex cross-assessments and cross-measurements of surveyed data, the most value contributions of this research are:

1. From a technology perspective on MOOCs Taiwanese websites, MOOCs websites have not only provided the evaluation technology, aggregation technology, professionalization technology in the course functions in order to efficiently raise the quality of courses and the professional recognition in public but it has also supply feedback technology and re-purposing technology functions in the course manipulated interplays of MOOC websites in order to effectively strengthen their assurance of MOOC's courses;
2. From an users' desire perspective on MOOCs websites, MOOCs websites have to further offer completely unrestricted operations, convenience and connectionized virtual education condition in order to attract additional internet users without MOOCs usage experience as well as the public at large who have personal time constraints but who have a desire to learn.

The significant findings of this paper are that (1) MOOC courses have to open the technological coding function of course content in order to interactively make the users not only login but to also upload their produced courses and (2) each MOOC user has to design the technological function to evaluate the course participating complete rate to confirm the public assurance of online learning condition and also to support MOOCs to be able to issue course certification to course' participants.

## REFERENCES

- Adamopoulos, G. I., & Pappis, C. P. (1996). A fuzzy-linguistic approach to multicriteria sequencing problem. *European Journal of Operational Research*, 92, 628 – 636. doi: 10.1016/0377-2217(95)00091-7
- Akao, Y. (1997).QFD: Past, present, and future. *In Proceedings of the international symposium on QFD*, 97, 1 – 12.

- Anderson, T., & McGreal, R. (2012). Disruptive pedagogies and technologies in universities. *Education, Technology and Society*, 15(4), 380–389.
- Ardis, M. A., & Henderson, P. B. (2012). Software engineering education (SEEd): Is software engineering ready for MOOCs? *ACM SIGSOFT Software Engineering Notes*, 37(5), 14–14. doi: 10.1145/2347696.2347720
- Bates, T. (2013). *Harvard's current thinking on MOOCs*. Retrieved from <http://tinyurl.com/a2uh86z>
- BBC. (British Broadcasting Corporation) (2012). *UK university applications down as fees rise*. Retrieved from <http://www.bbc.co.uk/news/education-16787948>
- Bell, F. (2010a). Connectivism: Its place in theory-informed research and innovation in technology-enabled learning. *The International Review of Research in Open and Distance Learning*, 12(3), 98–118.
- Bell, F. (2010b). Network theories for technology-enabled learning and social change: Connectivism and actor network theory. In L. Dirckinck-Holmfeld, V. Hodgson, C. Jones, M. de Laat, D. McConnell & T. Ryberg (Eds.), *Proceedings of the 7th International Conference on Networked Learning 2010*, 526–533.
- Bell, F. (2011c). Connectivism: Its place in theory-informed research and innovation in technology-enabled learning. *International Review of Research in Open and Distance Learning*, 12(3). Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/902/1664>
- Bevilacqua, M., Ciarapicab, F. E., & Giacchettab, G. (2006). A fuzzy-QFD approach to supplier selection. *Journal of Purchasing and Supply Management*, 12, 14–27. doi:10.1016/j.pursup.2006.02.001
- Bonino, R. (2012). International student mobility: Status, trends and possible impact of e-learning and social media, media applications for business, learning and society. *VCOBAM Conference Proceedings*, 3(1), 81–91.
- Bremer, C. (2012). New format for online courses: The open course future of learning. *Proceedings of eLearning Baltics eLba 2012*, 63 – 90. Retrieved from [http://www.bremer.cx/vortrag67/Artikel\\_elba2012\\_opco\\_bremer.pdf](http://www.bremer.cx/vortrag67/Artikel_elba2012_opco_bremer.pdf)
- Budak, I., & Kaygin, B. (2015). An investigation of mathematically promising students' cognitive abilities and their contributions to learning environment. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 25–36.
- Bull, D. D. (2012). From ripple to tsunami: The possible impact of MOOCs on higher education. *DEQuarterly*, 10–11.
- Butin, D. W. (2012). *What MIT should have done*. *eLearn Magazine*. Retrieved from <http://elearnmag.acm.org/featured.cfm?aid=2263018>
- Cabiria, J. (2012). Connectivist learning environments: Massive open online courses. *The 2012 World Congress in Computer Science Computer Engineering and Applied Computing*, 16 – 19. Retrieved from <http://elrond.informatik.tu-freiberg.de/papers/WorldComp2012/EEE6065.pdf>
- Campbell, T., Oh, P. S., Maughn, M., Kiriazis, N., & Zuwallack, R. (2015). A review of modeling pedagogies: Pedagogical functions, discursive acts, and technology in modeling instruction. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 159–176. doi: 10.12973/eurasia.2015.1314a
- Carey, K., (2013). *Obama, Rubio Agree on One Thing: Technology Could Fix the Higher Ed Mess*. Retrieved from <http://tinyurl.com/cogw2kh>
- Casey, D. M. (2008). The historical development of distance education through technology. *TechTrends*, 52(2), 45–51. doi: 10.1007/s11528-008-0135-z
- Casey, J. (2012), *Taking Care of Business? The political economy of MOOCs and Open Education*. Retrieved from <http://tinyurl.com/ao2agyc>
- Chamberlin, L., & Parish, T. (2011). MOOCs: Massive open online courses or massive and often obtuse courses? *eLearn Magazine*, August 2011. Retrieved from <http://elearnmag.acm.org/featured.cfm?aid=2016017>
- Chan, K. K. (2015). Salient beliefs of secondary school mathematic teachers using dynamic geometry software. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 139–148.
- Chang, Y. L., & Wu, H. K. (2015). A case study of increasing vocational high school teachers practices in designing interdisciplinary use of scientific inquiry in curriculum design.

- Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 37–51. doi: 10.12973/eurasia.2015.1304a
- Chen, S. H., Lin, H. T., & Lee, H. T. (2004). Enterprise partner selection for vocational education: Analytical Network Process. *International Journal of Manpower*, 25(7), 643 – 655. doi: 10.1108/01437720410563980
- Christensen, C., Johnson, C., & Horn, M. B. (2008). *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns*. Retrieved from <http://tinyurl.com/apnfhls>
- Coursera. (2013). Five courses receive college credit recommendations. Retrieved from <http://blog.coursera.org/post/42486198362/five-courses-receive-college-credit-recommendations>
- Daniel, J. (2012). Making sense of MOOCs: Musings in a maze of myth, paradox and possibility. *Journal of Interactive Media in Education*, 2012(3). Retrieved from <http://www.tonybates.ca/wp-content/uploads/Making-Sense-of-MOOCs.pdf>
- Deng, J. (1982). Control problems of grey systems. *Systems & Controls Letters*, 5, 288–294. doi: 10.1016/S0167-6911(82)80025-X
- Deng, J. (1989). Introduction to grey system theory. *The Journal of Grey System*, 1, 1–24.
- Deng, J. (1993). *Grey Control System* (pp. 146–158). Wuhan: HUST Press.
- Deng, J. (2005). *The Primary Methods of Grey System Theory* (pp. 165). Wuhan: HUST Press.
- DeWaard, I. (2011). Explore a new learning frontier: MOOCs. *Learning Solutions Magazine*. Retrieved from <http://www.learningsolutionsmag.com/articles/721/explore-a-new-learning-frontier-moocs/print>
- DeWaard, I., Abajian, S., Gallagher, M. S., Hogue, R., Keskin, N., Koutropoulos, A., & Rodriguez, O. C. (2011). Using m-Learning and MOOCs to understand chaos, emergence, and complexity in education. *The International Review of Research in Open and Distance Learning*, 12(7), 94–115. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/1046/2043>
- DeWaard, I., Koutropoulos, A., Keskin, N., Abajian, S. C., Hogue, R., Rodriguez, C. O., & Gallagher, M. S. (2011). Exploring the MOOC format as a pedagogical approach for m-Learning. In *Proceedings of 10th World Conference on Mobile and Contextual Learning*, 138–145.
- Downes, S. (2007a). Models for sustainable open educational resources. *Interdisciplinary Journal of Knowledge and Learning Objects*, 3. Retrieved from <http://www.ijklo.org/Volume3/IJKLOv3p029-044Downes.pdf>
- Downes, S. (2007b). *What connectivism is?* Paper presented at the Connectivism Conference, University of Manitoba, Winnipeg. Retrieved from <http://halfanhour.blogspot.com/2007/02/what-connectivism-is.html>
- Eilks, I. (2015). Science education and education for sustainable development – Justification, model, practices and perspectives. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 149–158.
- Engelbart, D. C. (1962). Augmenting human intellect: a conceptual framework. Summary Report for SRI Project No. 3578, *Stanford Research Institute*.
- Eren, M., Bulut, M., & Bulut, N. (2015). A content analysis study the usage of history of mathematics in textbooks in Turkey. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 53–62. doi: 10.12973/eurasia.2015.1305a
- Esposito, A. (2012). Research ethics in emerging forms of online learning: issues arising from a hypothetical study on a MOOC. *Electronic Journal of e-Learning*, 10(3), 315–325. Retrieved from <http://www.ejel.org/issue/download.html?idArticle=210>
- Fini, A. (2009). The technological dimension of a massive open online course: The Case of the CCK08 course tools. *The International Review of Research in Open and Distance Learning*, 10(5), 1–26. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/643/1410>
- Fournier, H., Kop, R., & Sitlia, H. (2011). The value of learning analytics to networked learning on a personal learning environment. *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*, 104–109.
- Frank, S. J. (2012). Review: MITx's online circuit and analysis course. *Spectrum IEEE*, 49(9), 27–28.
- Gao, F., Luo, T., & Zhang, K. (2012). Tweeting for learning: A critical analysis of research on microblogging in education published in 2008-2011. *British Journal of Educational Technology*, 43(5), 783–801. doi: 10.1111/j.1467-8535.2012.01357.x

- Han, S., Yalvac, B., Capraro, M. M., & Capraro, R. M. (2015). In-service teachers' implementation and understanding of STEM project based learning. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 63–76. doi: 10.12973/eurasia.2015.1306a
- Hauser, J. R., & Clausing, D. (1988). The house of quality, *The Harvard Business Review*, 3, 63–73.
- Hyman, P. (2012). In the year of disruptive education. *Communications of the ACM*, 55(12), 20–22. doi: 10.1145/2380656.2380664
- Jarrett, J. (2012), *What Are 'MOOC's and Why Are Education Leaders Interested in Them?* Retrieved from [http://www.huffingtonpost.com/impatient-optimists/what-are-moocs-and-why-ar\\_b\\_2123399.html](http://www.huffingtonpost.com/impatient-optimists/what-are-moocs-and-why-ar_b_2123399.html)
- JISC (Joint Information Systems Committee), (2013), *Open educational resources programme*. Retrieved from <http://www.jisc.ac.uk/whatwedo/programmes/elearning/oer.aspx>
- Kelland, J. H. (2006). Constructivist theories and online learning best practices: A discourse analysis. *Canadian Association for the Study of Adult Education (CASAE) 2006 National Conference On-Line Proceedings*. York University, Toronto, Ontario.
- Kim, M. K., & Cho, M. K. (2015). Design and implementation of integrated instruction of mathematics and science in Korea. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 3–15.
- Kirkwood, K. (2010). The wisdom of the clouds: Distributed learning, MOOCs, edupunks, and the challenge to formal education. In *Proceedings of the Second International Workshop on Open Source and Open Content (WOSOC) 2010*, 96–103. Gunadarma University, Jakarta, Indonesia.
- Kohil, S., & Kumar, E. (2011). Evolution of user dependent model to predict future usability of a search engine. In *Information and Communication Technologies (WICT), 2011 World Congress on Information and Communication Technologies*. 285–290.
- Kop, R., & Carroll, F. (2012). Cloud computing and creativity: Learning on a massive open online course. *European Journal of Open, Distance and E-Learning*. Retrieved from <http://www.eurodl.org/index.php?article=457>
- Kop, R., & Hill, A. (2008). Connectivism: Learning theory of the future or vestige of the past? *International Review of Research in Open and Distance Learning*, 9(3). Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/523/1103>
- Kop, R., Fournier, H., & Mak, J. S. F. (2011). A pedagogy of abundance or a pedagogy to support human beings? Participant support on massive open online courses. *International Review of Research in Open and Distance Learning, Special Issue - Emergent Learning, Connections, Design for Learning*, 12(7). Retrieved from <http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=rtdoc&an=19040607>
- Koutropoulos, A., & Hogue, R. J. (2012). How to succeed in a MOOC-Massive online open course. *eLearning Guild, October 08, 2012*. Retrieved from [http://www.cedma-europe.org/newsletter%20articles/eLearning%20Guild/How%20to%20Succeed%20in%20a%20MOOC%20-%20Massive%20Online%20Open%20Course%20\(Oct%202012\).pdf](http://www.cedma-europe.org/newsletter%20articles/eLearning%20Guild/How%20to%20Succeed%20in%20a%20MOOC%20-%20Massive%20Online%20Open%20Course%20(Oct%202012).pdf)
- Koutropoulos, A., Gallagher, M. S., Abajian, S. C., deWaard, I., Hogue, R. J., Keskin, N. Ö., & Rodriguez, C. O. (2012). Emotive vocabulary in MOOCs: Context & participant retention. *European Journal of Open, Distance and E-Learning*. Retrieved from <http://www.eurodl.org/?p=Special&sp=init2&article=507>
- Kukulska-Hulme, A., & Traxler, J. (2007). Designing for mobile and wireless learning. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age*, 183–192. New York: Routledge.
- Lane, A., & McAndrew, P. (2010). Are open educational resources systematic or systemic change agents for teaching practice? *British Journal of Educational Technology*, 41(6), 952–962. doi: 10.1111/j.1467-8535.2010.01119.x
- Laroche, L., Nicol, C., & Mayer-Smith, J. (2007). New venues for science teacher education: Self-organizational pedagogy on the edge of chaos. *Complicity: An International Journal of Complexity and Education*, 4(1), 69–83.
- Laurillard, D. (2007). Pedagogical forms for mobile learning. In N. Pachler (Ed.), *Mobile learning: Towards a research agenda* (pp. 153–175). London: WLE Centre, IoE.

- Levin, T. (2013). California bill seeks campus credit for online study. *The New York Times*. Retrieved from [http://www.nytimes.com/2013/03/13/education/california-bill-would-force-colleges-to-honor-online-classes.html?\\_r=1&](http://www.nytimes.com/2013/03/13/education/california-bill-would-force-colleges-to-honor-online-classes.html?_r=1&)
- Levy, D. (2011). Lessons learned from participating in a connectivist massive online open course (MOOC). *Proceedings of the Chais conference on instructional technologies research 2011: Learning in the technological era*. Eshet-Alkalai, Y., Caspi, A., Eden, S., Geri, N. & Yair, Y. (Eds.), The Open University of Israel, Raanana, 31–36. Retrieved from [http://www.openu.ac.il/research\\_center/chais2011/download/f-levyd-94\\_eng.pdf](http://www.openu.ac.il/research_center/chais2011/download/f-levyd-94_eng.pdf)
- Liyaganawardena, T. R. (2012). *Information communication technologies and distance education in Sri Lanka: A case study of two universities* (PhD Thesis). University of Reading, Reading.
- Mackness, J., Mak, S. & Williams, R. (2010). The ideals and reality of participating in a MOOC. *Proceedings of the 7th International Conference on Networked Learning 2010*, 266–275. University of Lancaster, Lancaster.
- Mahraj, K. (2012). Using information expertise to enhance massive open online courses. *Public Services Quarterly*, 8(4), 359–368. doi: 10.1080/15228959.2012.730415
- Mak, S., Williams, R., & Mackness, J. (2010). Blogs and forums as communication and learning tools in a MOOC. In *Networked Learning Conference*, University of Lancaster, Lancaster, 275–285.
- Martin, F. G. (2012). Will massive open online courses change how we teach? *Communications of the ACM*, 55(8), doi: 26–28. 10.1145/2240236.2240246
- Masters, K. (2011). A brief guide to understanding MOOCs. *The Internet Journal of Medical Education*, 1(2). doi: 10.5580/1f21
- McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). The MOOC model for digital practice, SSHRC Knowledge Synthesis Grant on the Digital Economy. Retrieved from [http://www.edukwest.com/wp-content/uploads/2011/07/MOOC\\_Final.pdf](http://www.edukwest.com/wp-content/uploads/2011/07/MOOC_Final.pdf)
- Mehaffy, G. L. (2012). Challenge and change. *EDUCAUSE Review*, September/October 2012, 25–41. Retrieved from <http://net.educause.edu/ir/library/pdf/ERM1252.pdf>
- Mehlenbacher, B. (2012). Massive open online courses (MOOCs): Educational innovation or threat to higher education? *Proceedings of the Workshop on Open Source and Design of Communication*, 1–99. doi: 10.1145/2316936.2316953
- Meyer, R. (2012). *What it's like to teach a MOOC (and what the heck's a MOOC?)*. Retrieved from <http://tinyurl.com/cdfvvyq>
- Opricovic, S., & Tzeng, G.H. (2003). Defuzzification within a multi-criteria decision model. *International Journal of Uncertainty Fuzziness and Knowledge-Based Systems*, 11(5), 635 – 652. doi: 10.1142/S0218488503002387
- Özdamar Keskin, N., & Metcalf, D. (2011). The current perspectives, theories and practices of mobile learning. *The Turkish Online Journal of Educational Technology*, 10(2), 202–208.
- Peters, M., (2008) Paper presented at Economic and Social Research Council (ERSC, UK) Seminar Series on “Education and the Knowledge Economy”, University of Bath.
- Ravenscroft, A. (2011). Dialogue and connectivism: A new approach to understanding and promoting dialogue-rich networked learning. *International Review of Research in Open and Distance Learning*, 12(3), 140–160. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/934/1829>
- Robbins, J. (2013). *The ethics of MOOCs*. Retrieved from <http://www.insidehighered.com/blogs/sounding-board/ethics-moocs>
- Roderick, S. (2008). Rethinking e-learning: A manifesto for connected generations. *Distance Education*, 29(2), 153–164. doi: 10.1080/01587910802154954
- Rodriguez, C. O. (2012). MOOCs and the AI-Stanford like courses: Two successful and distinct course formats for massive open online courses. *European Journal of Open, Distance and E-Learning*. Retrieved from <http://www.eurodl.org/?p=Special&sp=init2&article=516>
- Sahin, Z., Yenmez, A. A., & Erbas, A. K. (2015). Relational understanding of the derivative concept through mathematical modeling: A case study. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1), 177–188. doi: 10.12973/eurasia.2015.1149a
- Schrire, S., & Levy, D. (2012). Troubleshooting MOOCs: The case of a massive open online course at a college of education. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications, 2012(1)*, 761–766.

- Shih, H. S., Lin, W. Y., & Lee, E. S. (2001). Group decision making for TOPSIS. In *Joint 9<sup>th</sup> IFSA World Congress and 20<sup>th</sup> NAFIPS International Conference* (pp. 2712–2717). IFSA/NAFIPS, Vancouver, Canada.
- Shih, H. S., Shyurb, H. J., & Lee, E. S. (2007). An extension of TOPSIS for Group Decision Making. *Mathematical and Computer Modeling*, 45, 801–813. doi: 10.1016/j.mcm.2006.03.023
- Shih, H.S. (2008). Incremental analysis for MCDM with an application to group TOPSIS. *European Journal of Operational Research*, 186, 720–734. doi:10.1016/j.ejor.2007.02.012
- Shyura, H. J., & Shih, H. S. (2006). A hybrid MCDM model for strategic vendor selection. *Mathematical and Computer Modeling*, 44, 749–761. doi:10.1016/j.mcm.2005.04.018
- Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, 2(1), 3–10.
- Stewart, B. (2010). *Social media literacies and perceptions of value in open online courses*. Retrieved from [http://portfolio.cribchronicles.com/wp-content/uploads/2012/11/612701\\_Social\\_Media\\_Literacies\\_MOOCs.pdf](http://portfolio.cribchronicles.com/wp-content/uploads/2012/11/612701_Social_Media_Literacies_MOOCs.pdf)
- Traxler, J. (2010). *The learner experience of mobiles, mobility and connectedness*. Paper published by ELESIG (Evaluation of Learners' Experiences of e-Learning Special Interest Group). Retrieved from <http://www.helenwhitehead.com/elesig/ELESIG%20Mobilities%20ReviewPDF.pdf>
- Tschofen, C., & Mackness, J. (2012). Connectivism and dimensions of individual experience. *The International Review of Research in Open and Distance Learning*, 13(1), 124–143.
- Tsujimura, Y., Park, S. H., Chang, I. S., & Gen, M. (1993). An effective method for solving flow shop scheduling problems with fuzzy processing times. *Computer and Industrial Engineering*, 25, 239–242.
- Tsujumura, Y., Gen, M., & Kubota, E. (1993). Solving Fuzzy Assembly-Line Balancing Problem with Genetic Algorithms. *Computer and Industrial Engineering*, 29(1–4), 239–242. doi: 10.1016/0360-8352(93)90265-Y
- Vardi, M. Y. (2012). Will MOOCs destroy academia? *Communications of the ACM*, 55(11), 5. Retrieved from <http://dl.acm.org/citation.cfm?id=2366317>
- Vihavainen, A., Luukkainen, M., & Kurhila, J. (2012). Multi-faceted support for MOOC in programming. *SIGITE'12*, Calgary, Alberta, Canada, ACM. Retrieved from <http://sigite2012.sigite.org/wp-content/uploads/2012/08/session13-paper02.pdf>
- Vygotsky, L.S. (1978). Interaction between learning and development. In L. S. Vygotsky (Ed.), *Mind in society*. 79–91, Cambridge, MA: Harvard University Press.
- Weller, M. (2007). Learning objects, learning design, and adoption through succession. *Journal of Computing in Higher Education*, 19(1), 26–47.
- Wiley, D. A. (2003). *A modest history of Open Courseware*. Autounfocus blog. Retrieved from <http://www.reusability.org/blogs/david/archives/000044.html>
- Wiley, D. A. (2006). *The Current State of Open Educational Resources*. Retrieved from <http://opencontent.org/blog/archives/247>
- Wiley, D. A., & Hilton, J (2009). Openness, Dynamic Specialization, and the Disaggregated Future of Higher Education, Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/768/1414>
- Wiley, D. A., Recker, M. M., & Gibbons, A. (2000). *The reusability paradox*. Retrieved from <http://rclt.usu.edu/whitepapers/paradox.html>
- Winters, N. (2007). What is mobile learning? In M. Sharples (Ed.), *Big issues in mobile learning*, 7–11. Nottingham, UK: LSRI, University of Nottingham.
- Yoon, K., & Hwang, C. L. (1985). Manufacturing plant location analysis by multiple attribute decision making: Part I-Single-Plant strategy. *International Journal of Production Research*, 23(2), 345–359. doi: 10.1080/00207548508904712
- Yuan, L., MacNeill, S., & Kraan, W. (2008). Open Educational Resources-Opportunities and challenges for higher education, from [http://wiki.cetis.ac.uk/images/0/0b/OER\\_Briefing\\_Paper.pdf](http://wiki.cetis.ac.uk/images/0/0b/OER_Briefing_Paper.pdf) 1-34
- Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, 8, 338–353.

