UNIVERSITY OF GOTHENBURG

DEPARTMENT OF EDUCATION, COMMUNICATION & LEARNING

MOOC ADVANCEMENT: FROM DESKTOP TO MOBILE PHONE

An Examination of Mobile Learning Practices in Mobile Massive Open Online Course (MOOC)

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Thesis:	30 higher education credits
Program and/or course:	International Master's Programme in IT & Learning
Level:	Second Cycle
Semester/year:	Autumn term 2018
Supervisor 1:	Marisa Ponti
Supervisor 2:	Christian Stöhr
Examiner:	Markus Nivala
Report no:	HT18-2920-003-PDA699

Abstract

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Keywords:	MOOC, mobile learning, activity theory, activity oriented design model

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Purpose: The overarching goal of the study is to examine mobile learning practices in Massive Open Online Course (MOOC) setting. Furthermore, the goal is guiding the objectives of the study as to examine whether MOOC format enables mobile learning practice, followed by an attempt to investigate the pattern of learners' practices when using MOOC in mobile phones.

Theory: Activity Theory

Method: Descriptive and Correlational Data Analysis with Descriptive and Inferential Statistics

Results: The study showed that learners demonstrated temporal and space independence when being engaged with MOOC courses on mobile phones to some extent. However, some contradictions that challenge the concept of mobility were also found. Such as high usage of Wi-Fi despite that mobile data was available, and passive participation that was still dominant over active participation in discussion activity. In addition to video constraints that influence the mobile learners' engagement, it was proven that shorter videos are more likely to be completed, while follow-up quiz does not have an effect on video completion rate. In regards to the learners' profiles, the study found that learners' age does not have an effect on both video completion rate and forum participation. Besides, there were no statistical differences between different levels of educational background on video completion rate and forum participation. Nevertheless, more investigations and continuous research are encouraged to progress through the continuous development of technology and the evolution of learning pattern.

Foreword

This final assignment would not have been possible without support from many people. First and foremost, thank you to my supervisors, Marisa Ponti and Christian Stöhr for your guidance and feedback. Also, thank you to ChalmersX for providing me access to the data used in the study. The last but not the least, thank you for my family, closest one, and friends for your support. Finally, I hope this project fulfil its scientific purposes and contribute to the community.

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1. Introduction

Dhawal Shah (2018), founder of Class Central, a MOOC discovery platform, estimated 30 million users had been registered to Coursera in 2017, prompting it to be the biggest MOOC provider to date. Another major player, edX, has also drawn significant numbers of users for 14 million. Being a breakthrough in education, MOOC that is defined as open courses accessed through computer and mainly free for massive amounts of learners, has also attracted researchers from different theoretical and practical point of views over the years (Liyanagunawardena, Adams, & Williams, 2013; Yousef, Chatti, Schroeder, Wosnitza, & Jakobs, 2014). Following the successful journey in the computer environment, Coursera initiated the advancement of MOOC to the mobile app to enable 'learn on the go' in 2013 (TheNextWeb, 2013). It is arguably 'a breath of fresh air' in MOOC progression seeing the potential of mobile learning, in the first place. Ambient Insight reported that the worldwide market for mobile learning products and services is worth 8.4 billion USD in 2014. To say that mobile learning is mainstream is an understatement, considering how mobile phones with more advanced technology has become such a lifestyle. The tech-giant, Google, who surveyed in 2016 in the US found that 80% use smartphone and nearly 40% of people immediately use a smartphone for searching purpose. Additionally, according to a survey by Tecmark back in 2014, the average user in the UK uses their smartphone 221 times a day.

1.1. Problem Statement

In a broader context of learning, Motiwalla (2005) suggested that using mobile devices as learning tool offers extra value, such as personalisation possibility that potentially attract adult learners, especially if they are seeking for work-life balance. Even though mobile learning will never entirely replace classroom learning, if used accordingly, it can complement and add value to the established learning styles or methods (Liaw, Hatala, & Huang, 2010). The examples of mobile learning application, for instance, using Short Message Service (SMS) to send materials to students (Thornton & Houser, 2004), providing mobile app about anatomical models of human organs for medical students as study aid (Young, 2011), adding location-based information of landmarks with geolocation capability (Cheon, Lee, Crooks, & Song, 2012), or a simple case in biology class where students are assigned to collect flowers in a forest and share with other students through email or SMS. Besides, mobile learning promotes context awareness wherein the information delivered is relevant to learners' location and immediate needs (Londsdale, Baber, Sharples, & Arvanitis, 2004).

Meanwhile, in the context of e-learning, Sharples, Kloos, Dimitriadis, Garlatti, and Specht (2015) argued that the modern websites allow students to access learning materials on desktop and mobile to provide ubiquitous access. Further, they stated that, "*mobile and ubiquitous technology offers opportunities to extend the reach and value of massive open online courses*" (p. 6). In addition to that, other distinctive characteristics of mobile learning such as easy access for immediate needs (Wu & Chao, 2008), and mobility concerning location and time (Parsons, Ryu, & Cranshaw, 2007) can be useful for enhancing the learning experience in MOOC. Likewise, de Waard *et al.* (2011a) explored the combination of MOOC and mobile learning for informal and lifelong learning. They concluded that, "*both learning forms allow for knowledge creation to happen over time without being tied to a particular space and context*" (p. 147).

However, despite its potential, similar to MOOC and mobile learning which have limitations and challenges individually, an attempt to merge both formats is prone to problems. The originator of MOOC initially designed it for a desktop environment. Hence, shifting MOOC to mobile may initiate additional hurdles, both technically and pedagogically (Dalipi, Imran, Idrizi, & Aliu, 2017; Stöhr, 2017). In order to deliver proper mobile learning, one has to be aware of mobile device's limitations and advantages, thus cannot merely apply design requirement from e-learning to m-learning (Parsons *et al.*, 2007). Rothkrantz (2015) added that some adjustments might be required, particularly the used didactic model. It is due to difference regarding context, environmental condition, distraction, and physical constraints between desktop and mobile learning environment. Even though usability was not an issue, he showed that the differences above along with inappropriate didactic model hinder the use of mobile learning materials. It is corroborated by the study of Dalipi *et al.* (2017) who found that learners were frustrated when facing difficulty in performing tasks in mobile MOOC. Thus to utilise the advantages of mobile devices, MOOC needs to not only act upon its technical limitations but also adapt its learning format that will leverage mobile's unique features such as ubiquitous access and mobility (Stöhr, 2017).

The ongoing discussion earlier is leading to questions, is the current MOOC design ready to be transferred to the mobile device? Has MOOC format been adjusted to the mobile learning environment? How is the actual mobile learning practice in MOOC setting? Unfortunately, there has not been significant numbers of research addressing these questions apart from the studies mentioned above.

This study attempts to address the research gap by examining mobile learning practice in MOOC setting. To be more concrete, an empirical study of learners' practice pattern when using MOOC on the mobile device, mobile phones, in particular, will be provided. Finally, as quoted by de Waard *et al.* (2011a), "*it is the framework which changes with each new technology and not just the picture within the frame*" (McLuhan & Zingrone, 1997, p. 273), this study will also examine how mobile technology shapes a new way of learning.

1.2. Scope

The study selectively looks into three courses offered by ChalmersX MOOC in the edX platform from 2015 to 2017. The data is collected through the learning management system, learning analytics, and event interaction logs provided by edX thus the scope and elements of analysis heavily depend on the platform's limitation. Currently, edX only distinguishes the source of events coming from "browser" and "mobile application", further, there is no distinction between browser accessed from a desktop or laptop or mobile phone. Hence, the sample of the study involves explicitly only learners who use edX mobile application although a user can access the edX platform through the browser in mobile phones. Correspondingly, the source of events information is only available for video lecture interaction. As a consequence, the critical activity to be investigated is including but not limited to video lectures.

1.3. Goal, Objectives, and Research Questions of the Study

To begin with, the central goal of this study is to examine mobile learning practice in the Massive Open Online Course (MOOC) setting. The goal guides the objectives of the study as to examine whether MOOC format enables mobile learning practice, followed by an attempt to investigate the pattern of learners' practices when using MOOC on mobile phones.

In the process, the study is grounded upon an activity-based mobile learning theory developed by Sharples, Taylor, and Vavoula (2006), which mainly derived from Engeström's expansive model of activity system (1987). Subsequently, Activity-Oriented Design Model by Mwanza (2009) is applied as a framework for identifying analytical questions and developing a set of hypotheses concerning mobile learning practice in MOOC based on activity system theory. Altogether, the following research questions are formulated in a detailed manner by taking into account the objectives and the scope of the study. Lastly, the study focuses on answering research questions by analysing data and validating the hypotheses.

1) How do the format of the course, assessment, and community building in MOOC setting enable mobile learning practice?
2) What is the pattern of learners' practices when using MOOC in mobile phones by focusing on video lecture interaction and discussion activity?
3) Does the characteristic of video lecture in mobile MOOC such as video length and follow-up quiz, influence learner engagement in terms of video completion rate?

1.4. Significance of the Study

Despite its challenges and restrictions, MOOC has remarkably succeeded in introducing a new way of learning. On the other hand, mobile phones have become an integral part of not only education but also our everyday life. Hence, exploring the potential of integrating MOOC and mobile devices is significant for technology-enhanced learning and distance learning research area (Traxler, 2009). While most of the studies regarding MOOC and mobile learning heavily focused on technological perspective (de Waard *et al.*, 2011a), this study tries to enrich research findings by examining the pedagogical viewpoint, particularly the mobile learning concept. Furthermore, the study will also contribute to filling in the lack of empirical research in mobile MOOC practices.

1.5. Structure of Thesis Work

This thesis work is structured into 6 main sections. Section 1 introduces the field of the research. Section 2 gives the related works concerning MOOC and mobile learning field as the summary of literature review. Section 3 provides key concepts and relevant theories for the research. Section 4 elaborates the research methods along with the conceptual design and analytical framework applied in the research. Furthermore, section 4 also specifies the technical design including sampling design, data collection and analysis, and operationalization procedure. Section 5 mainly presents the findings of the study. Finally, section 6 discusses the findings based on the relevant theories and wraps it up with conclusion, limitations of the study, and further research recommendation.

2. Related Works

This section serves as a summary of the literature review that has been done concerning previous empirical studies in MOOC and mobile learning field. Besides, this section also highlights the gaps in the earlier researches that this study contributes to filling in.

As one of the biggest MOOC providers, Coursera launched its first mobile application in iOS in late 2013 (TheNextWeb, 2013). The provider claimed that the mobile app lets the students 'learn on the go', 'learning anywhere and anytime', and 'learning anywhere away from desktop and laptop'. Following Coursera, edX launched a mobile app for Android and iOS in 2014 (Stöhr, 2017). Similarly, edX also promoted 'learn on the go' and 'learning on your schedule. Anytime and anywhere' value through their mobile application. Despite the individual popularity of MOOC and mobile learning, MOOC advancement to the mobile environment is relatively new. Probably that is why there have not been a significant number of empirical studies in MOOC and mobile learning domain.

However, before the mobile advancement on major MOOC providers, de Waard *et al.* (2011a, 2012) initiated MobiMOOC project, which was a six weeks online course on mobile learning with MOOC format, connectivist-MOOC in particular. The purpose of the study was to examine MOOC format as a potential pedagogical approach to fit mobile learning based on mutual affordances of both contemporary teaching and learning format. In regards to mobile device usage in the course, 77.5% of the participants chose to access the course material through mobile devices although it was not required. The key factors were as follows: 61.3% suggested that mobile devices enabled location independence which means that the participants can easily participate in the learning process wherever they are. 56.8% of the participants also indicated temporal independence characteristic of mobile learning which means that they can access the material at a time and place that is comfortable for them, and the last 29.5% used a mobile device for personal preference. The study found interesting similarities between MOOC and mobile learning that are assimilated respectably to create a unique learning experience. Both can enable time & space autonomy, the potential community that is built, and contextualisation that takes place by sharing experiences with each other. While de Waard *et al.*'s study showed the potential of merging cMOOC and mobile learning experience, there is a need to also look into xMOOC as the popular MOOC setting nowadays.

Meanwhile, some other studies were more technological-oriented. Jiang, Zhuo, and Chen (2015) investigated important functions of mobile interactive model of MOOC when designing mobile MOOC platform. Xiao and Wang (2016) proposed a technology called context and cognitive state triggered feed-forward (C2F2) to remind learners of their disengagement states when using mobile MOOC for learning.

Several other studies that examined xMOOC setting were more critical towards mobile MOOC setting. Rothkranz (2015) investigated technical constraints of mobile learning environment after downloading e-learning materials, and lack of specific didactic models that limit the use of mobile devices for learning. Therefore, he proposed new didactic models, such as network learning, mastery learning, discovery learning, and blended learning. Meanwhile, Dalipi *et al.* (2017) investigated learners' experiences and emotional behaviours in desktop and mobile learning environment. He found that the majority of the participants still preferred desktop to mobile. Also, they experienced frustration when having difficulties in performing tasks with mobile devices. Tabuenca, Kalz, and Löhr (2017) corresponded by evaluating MoocCast, a screencast technology to project MOOC video lectures from mobile to TV or monitor. Similar to the previous study, 80% of the participants chose a laptop over a mobile phone to access MOOC. Moreover, despite the attractive mobility aspect of mobile learning, 72% of the participants preferred to access the course from home. A similarity can be drawn from these studies wherein they examined how user perceived the use of mobile device but never the actual practice of mobile learning in MOOC. More importantly, there is a need to conduct a study in a bigger scale to closely comprehend massive element of MOOC.

Stöhr (2017) who examined the use of mobile devices in MOOC through learning analytics and clickstream[1] data showed that only 12% of its participants accessed video lectures through mobile devices. However, the result did not describe in what manner the participants accessed the video lecture. Furthermore, there was no indication of the utilisation of the advantage of mobile learning. Nevertheless, he suggested that rather than focusing on technical constraints, next generation of mobile learning in MOOC needs to be accompanied by proper pedagogies and learning designs. All in all, as suggested by de Waard *et al.* (2011b), there should be more studies that incorporate practices, benefits, and challenges of MOOC and mobile learning to show their contributing dynamics.

Therefore, this study attempts to incorporate more comprehensive data including MOOC learning analytics and event interaction logs in clickstream level to give better description and understanding of mobile learning practice in MOOC on a bigger scale. Having the aim of examining mobile learning practices in mobile MOOC, this study establishes the following research questions: 1) How do the format of the course, assessment, and community building in MOOC setting enable mobile learning practice?; 2) What is the pattern of learners' practices when using MOOC in mobile phones by focusing on video lecture interaction and discussion activity?; 3) Does the characteristic of video lecture in mobile MOOC such as video length and follow-up quiz, influence learner engagement in terms of video completion rate?.

[1] Clickstream is a record of person’s activities on the internet, such as websites they visit, and how long they spend on each one (retrieved from https://dictionary.cambridge.org/dictionary/english/clickstream on May 11th, 2018)

3. Key Concepts and Theories

In this section, existing theoretical studies and empirical research are reviewed and compared to provide a factual and comprehensive overview of relevant theories, concepts, and findings. The primary focuses of this section are MOOC, mobile learning, activity theory, and how they are applied practically.

3.1. Massive Open Online Course (MOOC)

The original concepts of MOOC are mainly free, open access courses, and extensive participation displayed by massive numbers of enrolled learners. Critical elements of MOOC are defined in Figure 1, which are derived from its abbreviation (Yousef *et al.*, 2014).

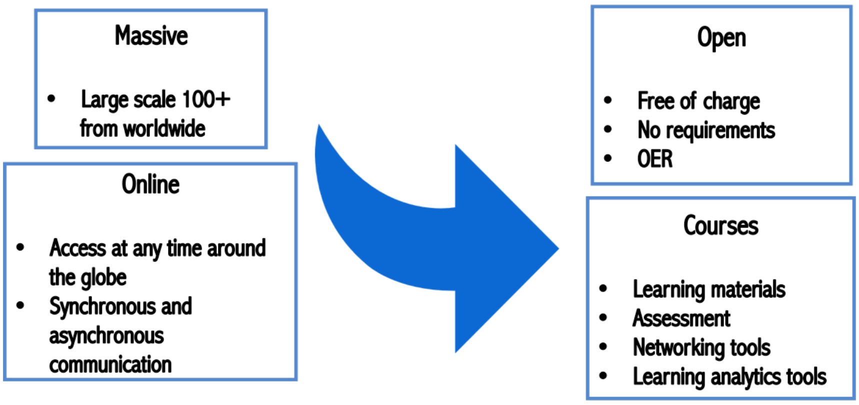

Figure 1. Critical Elements of MOOC (Yousef et al., 2014)

According to European Commission in the report on web skills survey in May 2014, MOOC is:

> "*an online course open to anyone without restrictions (free of charge and without a limit to attendance), usually structured around a set of learning goals in an area of study, which often runs over a specific period of time (with a beginning and end date) on an online platform which allows interactive possibilities (between peers or between students and instructors) that facilitate the creation of a learning community*" (p. 2).

The purpose of MOOC is solely for knowledge self-development and individual competence (Kesim & Altinpulluk, 2015). However, recently some providers may offer a chargeable certificate of completion but no entitled academic course credits (Brown, 2013; Kesim & Altinpulluk, 2015). Throughout the years, MOOC has introduced different types of format depending on the pedagogical design principles. The most common types are cMOOC and xMOOC (Yousef *et al.*, 2014; Kesim & Altinpulluk, 2015).

3.1.1. Connectivist-Massive Open Online Course (cMOOC)

The first generation of MOOC was named *connectivist*-MOOC (cMOOC) over a new learning theory proposed by Siemens called *connectivism* (Siemens, 2005; Downes, 2008 Liyanagunawardena et al., 2013; Yousef *et al.*, 2014; Anders, 2015). According to *connectivism*, learning is a process of connecting specialised sets of information in a network (Siemens, 2005; Downes, 2008; Anderson & Dron, 2011). Figure 2 illustrates fundamental concepts of cMOOC. Additionally, Kop (2011) suggested four major activities in cMOOC: 1) aggregation, collecting various resources; 2) relation, reflecting and relating them to previous experiences; 3) creation, creating individual content on social networking tools i.e. blog, Moodle, YouTube, Facebook, etc.; 4) sharing, connecting with community in the network by sharing the work and reviewing others.

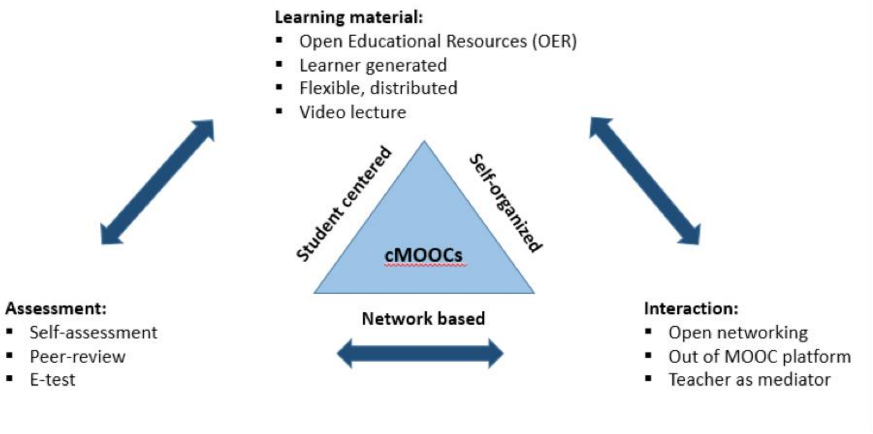

Figure 2. Key Concepts of cMOOC (Yousef et al., 2014; Kesim & Altinpulluk, 2015; Toven-Lindsey et al., 2015; Kaplan & Hainlein, 2016)

3.1.2. Extension-Massive Open Online Course (xMOOC)

The second type and common format nowadays, xMOOC, is based on traditional classroom lecture method. The University of Stanford initiated this type in 2011 by launching an online course on artificial intelligence for the public. The course had successfully attracted 160,000 registered students. Then MOOC era hit the breakthrough in 2012 when profit-based platforms were established such as Coursera, edX, and Udacity. On a side note, edX started as a non-profit joint platform between MIT and Harvard (Rodriguez, 2012; Liyanagunawardena *et al.*, 2013). Compared to cMOOC, xMOOC offers different concepts that are depicted in Figure 3. xMOOC focus on providing high-quality learning material delivered from teacher to learners (Yousef *et al.*, 2014; Anders, 2015) by using an instructional sequence to stimulate individual mastery (Toven-Lindsey, Rhoads, & Lozano, 2015). In xMOOC, learning objectives such as curriculum, timeline, and learning materials are pre-defined by teachers. The teachers transmit the knowledge through video lecture or digital presentation followed by assessments (Yousef *et al.*, 2014; Anders, 2015; Kesim & Altinpulluk, 2015). xMOOC also adopts the standard form of evaluation in a traditional classroom such as multiple choice assessment and topical group discussion (Toven-Lindsey *et al.*, 2015).

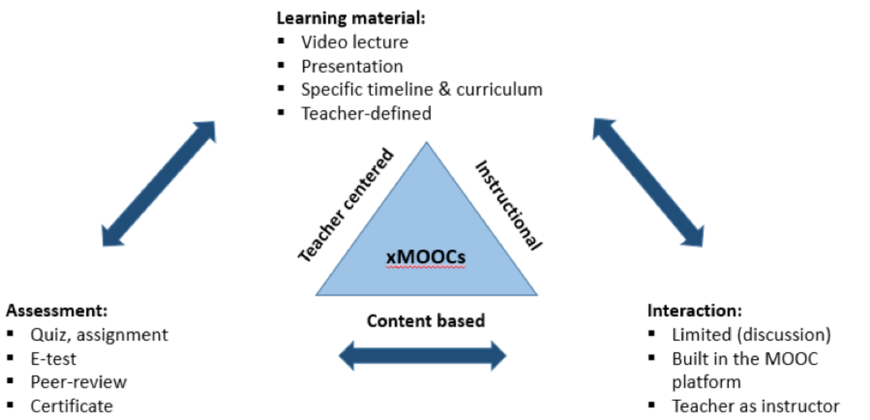

Figure 3. Key Concepts of xMOOC (Yousef et al., 2014; Kesim & Altinpulluk, 2015; Toven-Lindsey et al., 2015; Kaplan & Haenlein, 2016)

3.1.3. Learning Metaphors for MOOC

Sfard (1998) defined two kinds of metaphors in a learning experience: acquisition and participation. Acquisition metaphor put learning as knowledge acquisition and concept development in which learner is becoming the owner of these objects. On the other hand, participation metaphor conceives learning as a process of becoming specific community's member by interacting and communicating each other. Table 1 identifies two types of MOOC in regards to prior learning metaphors.

Table 1. Learning Metaphor Mapping of MOOC Types

Metaphor	**Criteria**	**cMOOC**	**xMOOC**
Acquisition	**Goal of Learning** Individual enrichment		✔
	Learning Acquisition of something		✔
	Student Recipient (consumer), re-(constructor)		✔
	Teacher Provider, facilitator, mediator	✔	✔
	Knowledge, concept Property, possession, commodity (individual, public)		✔
	Knowing Having, possessing		✔
Participation	**Goal of Learning** Community building	✔	
	Learning Becoming a participant	✔	
	Student Peripheral participant, apprentice	✔	
	Teacher Expert participant, preserver of practice	✔	
	Knowledge, concept Aspect of practice/discourse/activity	✔	
	Knowing Belonging, participating, communicating	✔	

As Table 1 illustrates, cMOOC is mainly within participation metaphor, meanwhile, xMOOC applies acquisition metaphor. However, Yousef *et al.* (2014) reported that xMOOC has progressed social and community development by promoting collaboration tools such as internal forums and wikis, although this type of communication is not mandatory for the course (Kaplan & Haenlein, 2016). One of the interesting findings in Table 1 is that the teacher criteria of cMOOC correlate with both acquisition and participation metaphors. In cMOOC, the teacher acts as a mediator between students rather than instructor of a one-to-many model. Additionally, a teacher in cMOOC is not necessarily an academic recognised master of the subject. A former participant who has been involved in the course and possessed mastery in managing social networking tools can also be the mediator.

3.2. Mobile Learning

Defining mobile learning is a discussion in itself because of the variety of definitions from different studies. This phenomenon cannot be avoided concerning that the field of research, as well as the technology, is still evolving (Hashemi, Azizinezhad, Najafi, & Nesari, 2011). These definitions reflect the point of interest of studies that use them. Peng, Su, Chou, and Tsai (2009) categorised the conceptualisations into three focus groups: functional components and communication style, mobility, and ubiquitous. Technology-focused studies in early years of mobile learning research typically used the first group definition. Quinn (2000) defined mobile learning as "*It's elearning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone*". Hoppe, Joiner, Milrad, and Sharples (2003) corresponded with the same analogy that mobile learning is simply a way of accessing e-learning with mobile devices and wireless transmission yet offers different learning experiences. Other than that, Chang, Sheu, and Chan (2003) identified three essential elements of mobile learning: mobile device, communication infrastructure, and learning activity model.

Further, the studies that Winters (2006) dubbed as technocentric specified which devices belong to mobile technologies category. He included PDA, mobile phone, iPod, and PlayStation Portable into the category. Likewise, in an earlier study, Chang *et al.* (2003) mentioned that mobile learning device could be PDA, WebPad, Tablet PC, notebook, or some specially designed tools. In a more comprehensive study, Naismith, Lonsdale, Vavoula, and Sharples (2002) classified mobile technologies based on two orthogonal dimensions of personal versus shared and portable versus static, as described in Figure 4. They argued that mobile technologies comprise all devices correlated with personal and portable dimensions, thus quadrant 1, 2 and 3.

In the early years of mobile learning, new technologies had influenced education fundamentally by providing an opportunity to mobilise computer usage from dedicated lab to classroom (Naismith *et al.*, 2002). Learning then has become 'mobile', and 'mobility' has been acknowledged to be the new foundation of mobile learning. Being mobile allows learning from anywhere (Hummel, Hlavacs, & Weissenböck, 2002; O'Malley *et al.*, 2005). Meanwhile, Kakihara and Sørensen (2002) argued that rather than just moving to different places, being mobile is also corresponding with how people interact with each other. They elaborated on mobility concept by examining three interrelated aspects of human interaction: spatial (where), temporal (when), and contextual. Similarly, Vavoula and Sharples (2002) described mobility with respect to space, different areas of life, and time.

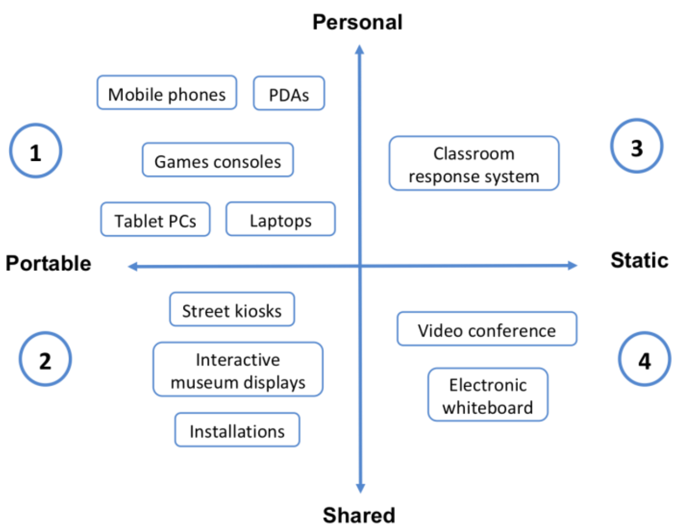

Figure 4. Classification of Mobile Technologies (Naismith et al., 2002)

Coming from the 'ubiquitous computing' term which means "*on-demand computing power which users can access computing technologies whenever and wherever they are needed*", Peng *et al.* (2009, p. 174) argued that ubiquity does not necessarily indicate anywhere and anytime notion in the earlier concept. Rather than that, ubiquity enables 'widespread', 'just-in-time', and 'when-needed' scenario for learners. In contrast, The Mobile Learning Network (MoLeNET) in 2010 argued that ubiquitous handheld technologies along with wireless and mobile phone networks enable learning to take place anywhere and anytime. Nevertheless, focusing on the definition and description of mobile learning especially from a technology perspective will be somewhat problematic, because it will move the attention away from its distinct features and pedagogical potentials to its technical constraints (Traxler, 2005). At the end of the spectrum, one can see the technology as a mediating tool in the learning process. Hence, there is a need for a conceptualisation of the notion of "*mobile learning as part of greater whole in which learning tools, activities, contexts, and people are distributed over time and space*" (Winters, 2006, p. 7).

3.3. Activity Theory

Activity theory is a common theory used in fields such as learning and teaching, and human-computer interaction (Engeström & Miettinen, 1999). Vygotsky, Leont'ev, and Luria initiated the theory in the 1920s and 1930s. Since then, the theory has evolved through several developments. It has also been criticised and evaluated by different scholars. Engeström specified at least three theoretical generations in the evolution of cultural-historical activity theory. The first generation focused on Vygotsky's famous triangular model of "*a complex, mediated act which is commonly expressed as the triad of subject, object, and mediating artifact*" (p. 5). Then, Leont'ev elaborated the second generation to overcome the limitation of the first generation where the unit of analysis remained individually focused. Leont'ev's "*primaeval collective hunt*" case example showed that historically evolving division of labour had promoted the critical difference between individual action and collective activity. Nevertheless, he has never formed an actual graphical model of a collective activity system. It was Engeström who introduced the third generation by incorporating two interacting activity systems (Kaptelinin, 2005).

Engeström expanded the activity system model depicted in Figure 5 that uses his work in activity theory as a case study. Sharples *et al.* (2006) defined six elements in Engeström's expansive model as follows: 1) subject as the focus of analysis; 2) mediating artifacts consist of tools or signs; 3) object as material or problem at which the activity is directed for; 4) community which represents multiple individuals and/or groups who share the same object; 5) rules which specify explicit and implicit regulations, norms, constraints, and conventions that control actions and interactions within activity system; 6) division of labour that carries out different roles, power, status, division of tasks, or authorisation.

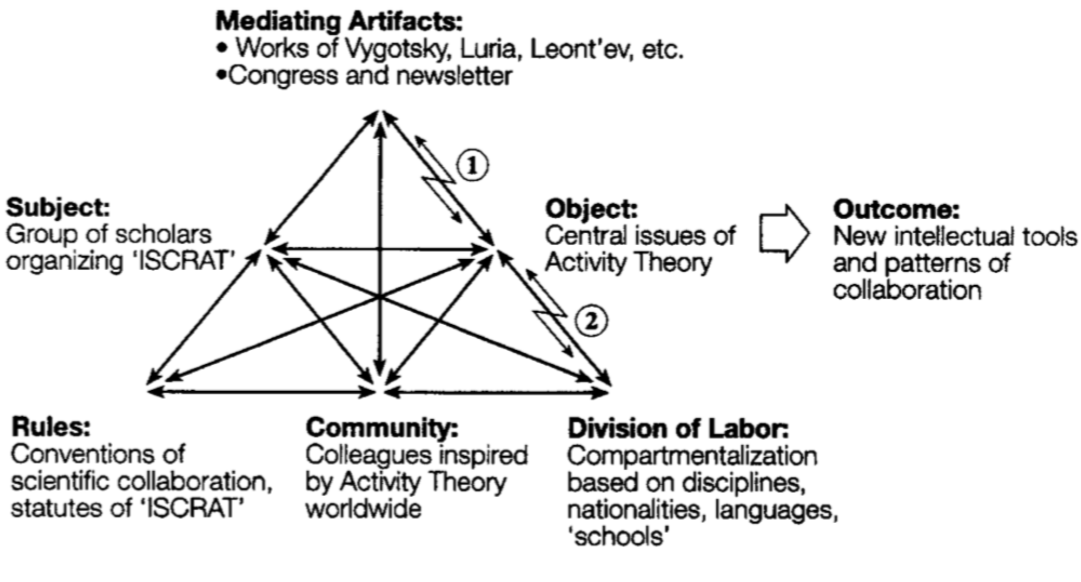

Figure 5. Expansive Model of Activity System by Engestörm (Engestörm, 1999a)

Following Engeström's expansive model, Sharples *et al.* (2006) presented two perspectives of tool-mediated activity to highlight the role of technology in learning. The semiotic layer describes learning as a semiotic system in which cultural tools and signs mediate the learner's actions. Meanwhile, the technological layer defines learning as:

> "*an engagement with technology, in which tools such as computers and mobile phones function as interactive agents in the process of coming to know, creating a human-technology system to communicate, to mediate agreements between learners (as with spreadsheets, tables and concept maps) and to aid recall and reflection (as with weblogs and online discussion lists)*" (p. 231).

Figure 6 below illustrates Sharples *et al.*'s framework model for analysing mobile learning. The figure shows two different layers in each of the elements of the activity system. If the semiotic layer has the original elements from Engeström's expansive model in Figure 5 such as rules, community, and division of labour, the technological layer proposed by Sharples et al. (2006) is represented by control, context, and communication.

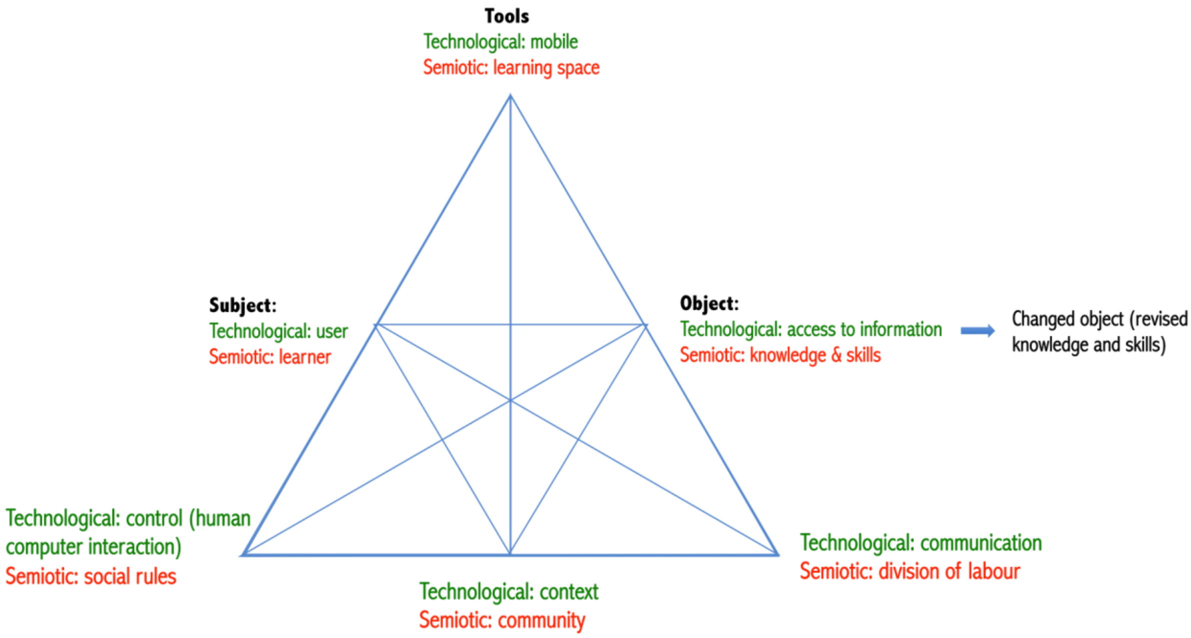

Figure 6. Framework for Analysing Mobile Learning (Sharples, Taylor, & Vavoula, 2006)

Sharples *et al.* (2006) argued that there is a dialectical relationship between nodes in the two perspectives of the mobile learning framework proposed above. The relationship showcases the process of appropriation in learning environment supported by technology. He illustrated a case when people evaluate potentials and limitations of a new tool, it is either they will adjust how the instrument works to their activities, or they change behaviour to fit the distinct feature of the instrument. Hence, there is a continuous development of a new way of interacting with technology and new learning patterns within individuals or communities. Correspondingly, Sharples *et al.* (2006) pointed out Engeström's (1987) argument of an activity system:

> "*Activity is a collective, systemic formation that has a complex mediational structure. An activity system produces actions and is realized by means of actions. However, activity is not reducible to actions. Actions are relatively short-lived and have a temporally clear-cut beginning and end. Activity systems evolve over lengthy period of socio-historical time, often taking the form of institutions and organizations.*" (p. 234)

4. Methods

Kumar (2011) identified three different perspectives in classifying the type of research: applications of the findings of the research study, mode of enquiry used in conducting the study, and objectives of the study. Following him, based on the first perspective, this study is classified as applied research which means that the research implements the research techniques, procedures and methods on the collection of information about various situations, issues, or phenomenon. Meanwhile, based on enquiry mode perspective, this study leans toward structured approach concerning the process to answer the research questions. It means that everything that assembles the research process – objectives, design, sample, attributes, and variables – is predetermined. To classify research into one specific type based on objectives perspective could be a bit problematic, because even though Kumar categorised the types into descriptive, correlational, explanatory, and exploratory, in practice, most studies are a combination of these types. A research is classified as a descriptive study if it describes a situation, problem, phenomenon, service or program systematically. In this case, the research will describe and examine the format of the course, assessment, and community building of MOOC that will enable mobile learning. Further, the research is also considered as correlational for trying to determine relationships between multiple elements in mobile MOOC learning activity to investigate the learners' practices pattern. Hence, rather than defining the research method into a specific type strictly, research can be defined as a process. In summary, the approach that is undertaken in the research is applied, structured, descriptive, as well as correlational.

To describe research as a process approach in which research question or hypothesis drives all decisions in the different stages of research, Tobi and Kampen's Methodology for Interdisciplinary Research framework (2017) is applied in this study. However, rather than justify it based on whether this study is interdisciplinary research or not, the motivation is simply because the framework is a pragmatic and feasible design process to conduct the research. Tobi and Kampen (2017) built the framework based on the process approach by Kumar (2011). Figure 7 depicts the Methodology of Interdisciplinary Research framework that is applied in this study.

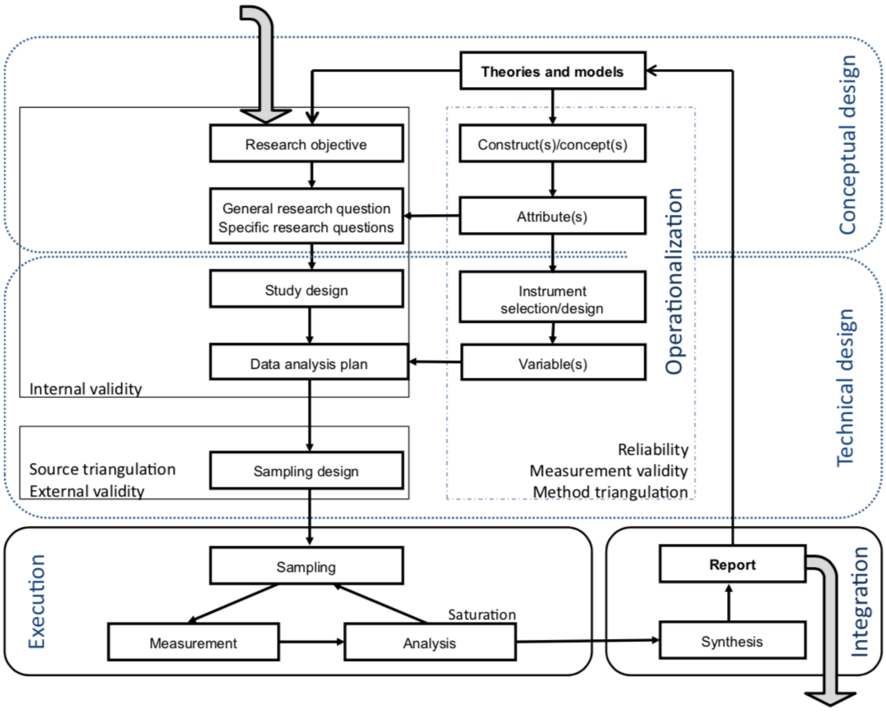

Figure 7. The Methodology of Interdisciplinary Research Framework (Tobi & Kampen, 2017)

4.1. The Conceptual Design

According to the Methodology of Interdisciplinary Research framework, a conceptual design is formulated by comprising research objectives, research questions, fundamental theory or theories, and the partial operationalisation of constructs and concepts that will be investigated during execution stage (Tobi & Kampen, 2017). Further, Tobi described operationalisation procedure as the port-folio approach to widely define what to be measured in a research. After identifying all the variables and components of measurement, research questions and hypothesis can be seen as an operational statement, such as, what are the means and variances of X1, X2, and X3 in a given population? Accordingly, the model to formulate the conceptual design of the study is presented in Figure 8. The figure illustrates the main objective that is broken down into examining MOOC format that enables mobile learning based on Sharples *et al.*'s theory of mobile learning, and investigating the pattern of mobile learning practice in MOOC with Activity-Oriented Design Model as analytical framework. Both Sharples *et al.* and Mwanza derived their work from Engeström's activity theory. Therefore, the overall relationships will be analysed as mobile learning activity with mobile MOOC as the mediating tool.

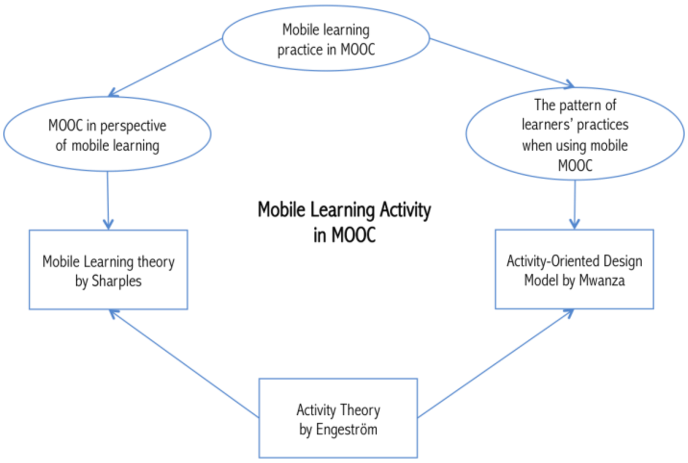

Figure 8. Formulation Model for the Research's Conceptual Design

4.1.1. Sharples *et al.*'s Theory of Mobile Learning Criteria to Examine MOOC Format

The danger of technology-focused concept can be seen when examining whether a laptop or tablet delivers mobile learning (Traxler, 2005). It is portable, featured with the wireless network, but can we learn using it anywhere and anytime? In contrast, going from the learner's perspective might enlighten what it is to be considered mobile. Furthermore, Traxler (2005) specified words such as spontaneous, private, informal, lightweight, and context-aware to describe mobile learning. Apparently, we can distinguish mobile learning and traditional learning using these words. However, the remaining question is whether we can use these words to distinguish mobile learning and e-learning.

Similar in idea to move away from technology-centred, Winters (2006) suggested to viewing mobile learning applications as a mediating tool in a learning process. He also added several other factors that mediate learning, named contexts, curriculum, cultures, ethics, learning activity, access to information and people, communication, community building, and appropriation. Hence, rather than taking technology as the primary role, taking into account social factors such as communication and appropriation as well as learning activities, can leverage the technology in intriguing ways.

Sharples *et al.* (2006) corresponded to the idea above by examining the theory that taking into account the uniqueness of mobile learning while referencing the principles of successful learning. He argued that the fundamental characteristic of mobile learning is 'mobility' in a sense that learners are continually on the move. Learners not only learn across space but also across time by reflecting previous knowledge in different context. Mobile learning enables learning outside of a traditional classroom context thus supports informal learning. The mobility and flexibility of the learning experience become possible because mobile learning does utilise the ubiquity of personal and shared technology. However, Sharples *et al.* (2006) argued that to support mobile learning, one does not necessarily use a portable device. He defined mobile learning as learning with portable technology, as well as learning with the mobility of people and knowledge. Therefore, Sharples *et al.* (2006) attempted to examine a "*distributed system in which people and technology interact to create and share meaning*" by describing the activity system of mobile learning. The analysis delineates cultural-history activity theory based on an adapted version of Engeström's expansive activity model (p. 230).

Apart from the original elements of activity system from Leont'ev, subject – mediating tools – object, Sharples *et al.* (2006) proposed a technological layer to complement the semiotic layer from Engeström's activity model. The semiotic layer represents social rules, community, and division of labour. Meanwhile, Sharples *et al.* (2006) specified control, context, and communication as elements in the technological layer. The study uses Sharples *et al.*'s criteria to examine the format of MOOC that enables mobile learning. Correspondingly, to analyse mobile learning as a collective activity that shows interactions between tool-mediated activity and both semiotic and the technological layers, the study will incorporate the mobile learning criteria and activity system components of both layers as outlined in Table 2.

Table 2. Mobile Learning Criteria & Activity Components (Sharples et al., 2006)

Criteria	**Activity Components**	
	Semiotic	Technological
Is it significantly different from current theories of classroom, workplace or lifelong learning? Does it account for the mobility of learners? Does it cover both formal and informal learning? Does it theorise learning as a constructive and social process? Does it analyse learning as a personal and situated activity mediated by technology?	Rules Community Division of Labour	Control Context Communication

4.1.2. Activity-Oriented Design Model (AODM) as Analytical Framework for Mobile Learners' Practices

As a framework to examine learners' practices in learning mediated by tools, AODM is based on Engeström's expansive model of activity system (Mwanza, 2009, 2011). Mwanza (2011) defined AODM as:

> "*activity theory based iterative approach to analysing and characterising learner practices with tools and technologies whilst paying attention to learner motives, and social-cultural issues that exist in the context in which learning activities are carried out*". (p. 78)

Driven by the objective of the study to investigate the pattern of learners' practices when using MOOC on mobile phones, the framework helps to formulate the hypotheses and address our research questions according to activity system theory. This section presents four methodological tools from AODM that are used to identify critical elements of human activity system and examine the inter-relationships between them.

4.1.2.1. Eight-Step-Model

The Eight-Step-Model helps to identify the various components of Engeström's activity model which are specific to the context of the activity that is being investigated (Mwanza, 2009, 2011). In summary, Mwanza identified eight elements of activity system as follows: activity of interest, object-ive, subjects, tools, rules and regulations, division of labour, community, and outcome.

In the original version of AODM, Mwanza (2009) interpreted the "object" element in Engeström's activity model as "*the motivational or purposeful nature of human activity*". Subsequent to this, the "object of activity" has been a discussion in activity theory-based research (Kaptelinin, 2005), as the theory has been evolving and interpreted by different scholars. On the other hand, based on his expansive model of activity system, Engeström defined "the object of activity" as "*the 'raw material' of 'problem space' at which the activity is directed and which is molded and transformed into outcomes*" (quoted by Kaptelinin, 2005, p. 10, from Center for Activity Theory and Developmental Work Research). Accordingly, Kaptelinin summarised two different perspectives of the object of activity as specified in Table 3.

Table 3. Two Perspectives on the Object of Activity (Kaptelinin, 2005, p.11)

Facets of Activity	**Leont'ev**	**Engeström**
Activities are carried out by	Individuals (predominantly)	Communities
Activities are performed	Both individually and collectively	Collectively
The object of activity is related to	Motivation, need ("the true motive")	Production (what is being transformed into the outcome)
Application domain	Psychology	Organisational change

Hence, rather than the "objective", Engeström's definition of the "object of activity" as 'raw material' was used when implementing the Eight-Step-Model in this study. The literal definition of 'raw material' is natural and processed material that can be converted by manufacture, processing, or combination into a new and useful product (Merriam-webster). Engeström used this term since his theory of human activity system mainly originated from manufacturing context. In the context of mobile MOOC learning activity, this study suggested that the learning activity is directed at the learning content in the course, for instance, video lectures, textbook, lectures, or assignment as the 'raw material'.

In section 3.2, Naismith *et al.* (2002) classified laptop or tablet PC as mobile devices because of its portability. However, Traxler (2009) argued that learning that is mediated by laptop or tablet PC should not be accounted as mobile learning. The reason is that laptop or tablet PC is less personal and habitual than mobile phones, people rarely carry their laptop or tablet PC without premeditated purpose. Following Traxler's argument, this study also used limited data that only distinguish the source of user interaction data from browser and mobile app. If a user is using a laptop, he will naturally use a browser. Currently, there is no distinction of browser accessed from a desktop, laptop, or mobile phones in the data source from edX event interaction logs. Thus the mediating tool involved in the activity system was specific to mobile MOOC application.

Furthermore, the definition of Division of Labour is different roles and responsibilities when carrying out the activity. In regards to this, Engeström (1999a) gave an example that Division of Labour can also represent different socio-cultural backgrounds such as disciplines, nationalities, languages, or educations (See Figure 5). Since this study focused on learner perspective, it makes sense to take into account the various socio-cultural backgrounds of the learners.

Other than that, the question to ask for "community" component was revised to represent multiple individuals or groups who share the same object of activity in the system. Since learning activity in MOOC is quite broad, it was found to be tricky to define "rules and regulations" when trying to identify interesting components of the activity system. One helpful step was to define which actions to be focused on to narrow down the scope. In this case, learners' practices when interacting with video lectures on mobile phones, was the main interest. Therefore, the rules or regulations that affect the specified action could be defined. All things considered, the implementation of Mwanza's Eight-Step-Model with some modifications are specified in Table 4.

Table 4. Revised Version of the Eight-Step-Model by Mwanza (2009, 2011)

The Revised Eight-Step-Model			
Identify the:		Questions to Ask	Components
1	Activity of interest	What sort of activity am I interested in?	Learning in MOOC (acquisition & participation)
2	Object of Activity	What is the 'raw material' or 'problem space' at which the activity is directed?	Learning content, e.g. video lectures
3	Subjects	Who is involved in carrying out this activity?	Learner
4	Tools	By what means are the subjects performing this activity?	MOOC mobile app
5	Actions	What actions am I interested in?	Interact with video lectures
	Rules & Regulations	Are there any cultural norms, rules or regulations governing the performance of this activity	Video interaction: Video constraints & characteristics, e.g. length, follow-up quiz
6	Division of Labour	Who is responsible for what, when carrying out this activity and how are the roles organised?	Different age, educational background
7	Community	What groups are interested in the same object at which the activity is directed?	Discussion forum
8	Outcome	What is the desired outcome from carrying out this activity?	Course completion, Course certificate

4.1.2.2. Activity Notation

Mwanza (2011) explained activity notation step as to "r*educe complexity in activity analysis by facilitating modelling and decomposition of activity systems in order to produce sub-activity systems*" (p. 80). In the original version, Mwanza still refers the "object of activity" to the "object-ive" or "purpose". To be consistent, other steps deliberately referred the "object of activity" to Engeström's definition. Table 5 defines the sub-activity systems according to Activity-Oriented Design Model (AODM). Following the notations below, one can see it as an attempt to break down a complex activity system into several dimensions that describe inter-relationships between the elements.

Table 5. AODM's Activity Notation (Mwanza, 2009, 2011)

The Activity Notation				
Actors (Doers)		Mediator		Object
Subjects	––	Tools	––	Object
Subjects	––	Rules	––	Object
Subjects	––	Division of Labour	––	Object
Community	––	Tools	––	Object
Community	––	Rules	––	Object
Community	––	Division of Labour	––	Object

4.1.2.3. Technique of Generating Research Questions

Based on the activity notation, Mwanza (2009, 2011) generated general research questions to guide the formulation of more focused topics of the research. Rather than used for global research questions, these questions are composed to support data gathering and analysis from Activity Theory (Mwanza, 2009). Further, the questions can also be the baseline for analysing user (subject) interaction with each other as well as with tools or technologies for mediating the activity (Mwanza, 2009, 2011). In this step, the general research questions are revised to reflect the change in the "object of activity" definition.

When it comes to Community – Tools – Object dimension, watching video lecture action does not make sense anymore. As in MOOC, watching video lecture is more of an individual experience. Group of friends can make an appointment to watch the video together, but it is unlikely for members of the community to arrange a schedule for viewing video lecture. Furthermore, it does not correspond to the personalised learning of MOOC. If we go back to the "object of activity" component, which is the learning content, the interesting question is what action can the members of the community do to interact with the learning content? Different from individual learner viewpoint, the community consists of collective participation hence one needs to interact with each other. According to participation metaphor, learning can be seen as a process of becoming specific community's member by interacting and communicating each other (Sfard, 1998). Thus, discussing learning content between learners can be seen as an action within a community. Discussion rules can also be added to the activity system model. Figure 9 illustrates Engeström's expansive model of mobile MOOC learning activity including discussion action.

A point of reflection was extracted from the analytical process so far. Rather than a linear process, Activity-Oriented Design Model was proven to be an iterative process to identify the activity system components and its relationships to meet the research's needs. Finally, the analytical questions can be generated based on identified components and sub-activity dimensions, as listed in Table 6.

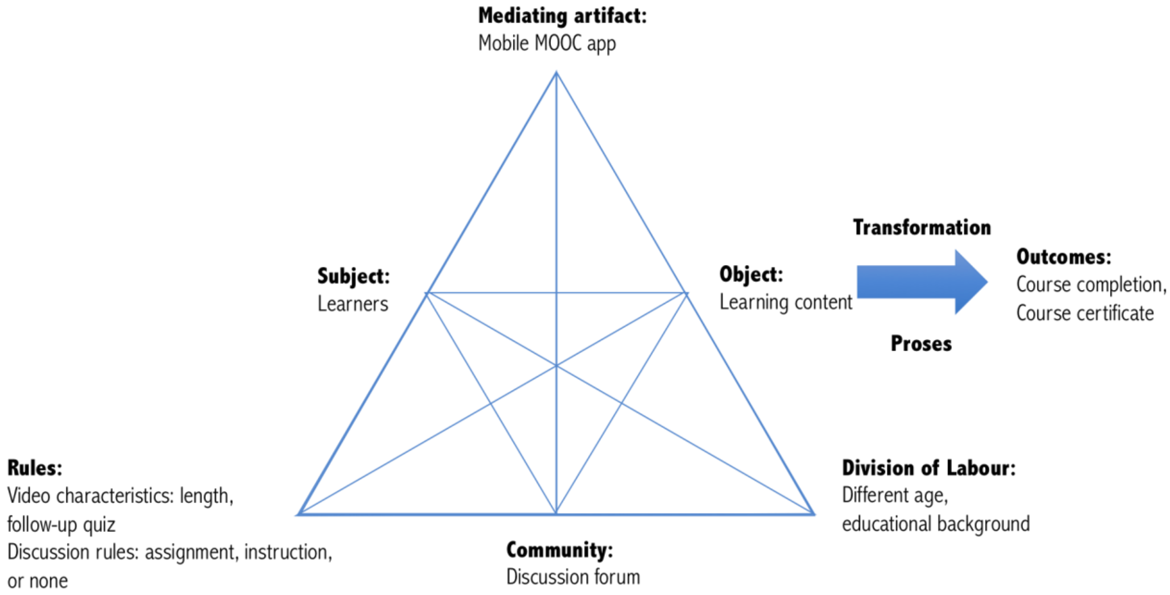

Figure 9. Expansive Model of Mobile MOOC Learning Activity

Table 6. The Generated Analytical Questions from AODM's General Research Questions (Mwanza, 2009, 2011)

General Research Questions	Analytical Questions
What Tools do the Subjects use to interact with the Object and how?	What is the pattern of learners' practices when using mobile MOOC to interact with video lectures?
What Rules affect the way the Subjects interact with the Object and how?	Does the characteristics of video lecture such as video length and follow-up quiz correlate to the way learners interact with them?
How does the Division of Labour influence the way the Subjects interact with the Object?	Do different age and educational backgrounds correlate to the way learners interact with video lecture?
How do the Tools in use affect the way Community interact with the Object?	What is the pattern of forum participants' practices when participating in discussions of learning content?
What Rules affect the way the Community interacts with the Object?	Do different settings of discussion in the course influence the way the forum participants participating in discussions of learning content?
How does the Division of Labour affect the way the Community interacts with the Object?	Do different age and educational backgrounds correlate to the way forum participants participating in discussions of learning content?

4.1.2.4. Technique of Mapping Operational Processes

This step is supposedly the last step in overall activity theory-based research according to AODM. The technique is used to "*interpret and communicate research findings by presenting visual representations of the transition of activities, sub-activities, activity components and relations, also contradictions or problems identified in focused activities*" (Mwanza, 2011, p. 81). The visual representation of operational process mapping in AODM is depicted in Figure 10. Overall, Mwanza (2009) specified six iterative stages in activity-theory based research supported by AODM methodological tools:

1) Interpret the situation being examined in terms of activity theory
2) Model the situation being examined
3) Decompose the situation
4) Generate research questions
5) Conduct a detailed investigation
6) Interpret and communicate findings

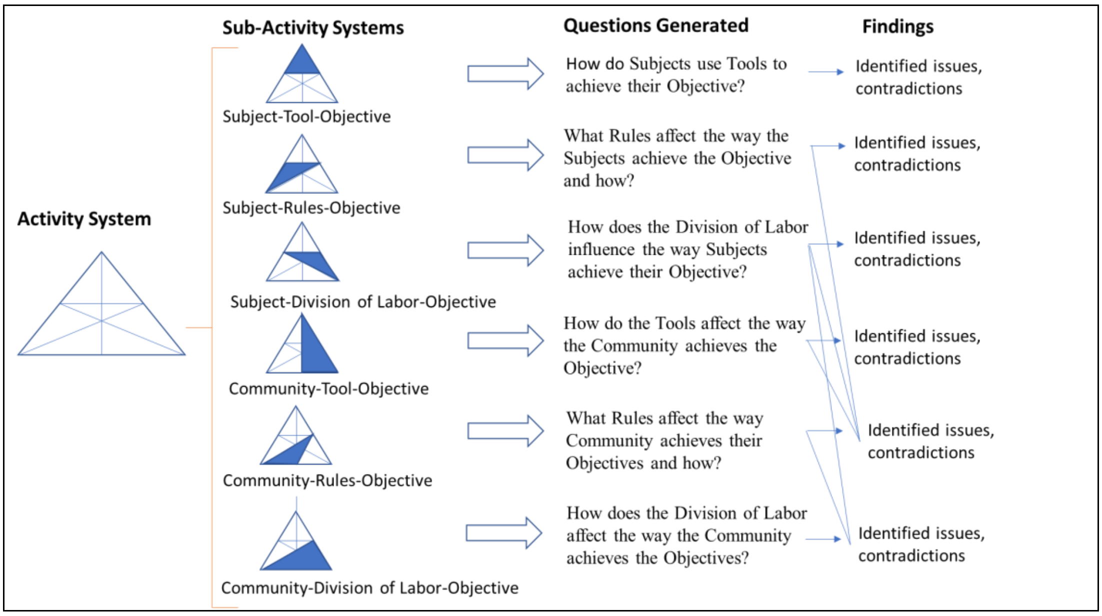

Figure 10. Operational Process Mapping in AODM (Mwanza, 2009, 2011)

4.1.2.5. Focus and Hypotheses Development

Based on the analytical questions established from generating research questions step earlier (see section 4.1.2.3), the focus of research was developed for each of the sub-activity dimensions by incorporating the activity system components and literature review. In this case, the focus of research was executed in a descriptive manner or by developing a set of hypotheses. Overall, the focus of research for the sub-activity dimensions is outlined in Table 7. Meanwhile, the next part of this section elaborates the specified focus based on previous studies.

Table 7. The Focus of Research for Sub-activity Dimensions

Sub-activity Dimension	Descriptive	Correlational with Hypothesis
Subject – Tool – Object	✔	
Subject – Rules – Object		✔
Subject – Division of Labour – Object		✔
Community – Tool – Object	✔	
Community – Rules – Object	✔	
Community – Dvision of Labour - Object		✔

1) Subject – Tool – Object Dimension

de Waard *et al.* (2011a) conducted a post-course survey of MobiMOOC, a MOOC about mobile learning which can be accessed through mobile devices. 77.5% of the participants chose to access learning material via mobile devices. The key factors were location and temporal independence of mobile learning, which means that learners can access the material at a place or time that is convenient for them. To discover learners' practices in mobile MOOC learning, this study focuses on investigating whether learners apply the advantage of mobile devices in terms of interacting with video lectures. For an example, an examination whether learners can easily progress wherever and whenever is conducted.

2) Subject – Rules – Object Dimension

Guo, Kim, and Rubin (2014) presented an empirical study of students' engagement with video lectures in MOOC, measured by how long they watch the video and whether they attempt to answer post-video assessment problems. The study found that video length is the most significant indicator of engagement. Further, he suggested that short videos are more engaging. The study also recommended that videos are ideally less than 6 minutes.

> *Hypothesis 1: Video length has a negative effect on video completion rate.*
> *Null H1: Video length does not have an effect on video completion rate.*

Kovacs's study (2016) found that users engaged significantly with in-video quizzes, 74% of the viewers attempted to answer the quiz. He also suggested that video dropout rate is lower in lectures that have in-video quizzes compared to other lectures that lack in-video quizzes.

> *Hypothesis 2: Follow-up quiz has an effect on video completion rate.*
> *Null H2: Follow-up quiz does not have an effect on video completion rate.*

3) Subject – Division of Labour – Object Dimension

Stöhr (2017) examined the use of mobile devices in MOOC and analysed the different backgrounds of the learners, such as age, gender, education, and geographical distribution. In summary, he concluded that learners who use mobile devices tend to be younger, male, and having education at least college degree but not advanced degree. However, he suggested that the difference is fairly insignificant.

> *Hypothesis 3: Age has a negative effect on video completion rate.*
> *Null H3: Age does not have an effect on video completion rate.*

> *Hypothesis 4: There is a significant difference between different levels of educational background on video completion rate.*
> *Null H4: There is no significant difference between different levels of educational background on video completion rate.*

4) Community – Tool – Object Dimension

Since mobile learning enables location and temporal independence, learners have more flexibility to participate in a discussion forum. In addition, Motiwalla (2007) investigated the use of wireless devices in higher education. He revealed that most of the participants agreed that mobile devices "allow instant access regardless of your location" and "allow convenient access to discussions – anywhere and anytime" with 4.27 and 4.05 average points respectively (from 5 Likert's scale). In order to determine the pattern of discussion practices in mobile MOOC learning, this study focuses on investigating forum participants' ubiquitous access to participate in discussions wherever and whenever.

5) Community – Rules – Object Dimension

Karlsson and Godhe (2016) argued that MOOC contains rules to control what to be achieved in the course, such as assessment and grading criteria. Further, these rules influence how the community is built within the MOOC environment. They particularly pointed out the lack of structure in cMOOC that makes it difficult for learners to participate in the community without guidance. In contrast, courses in xMOOC are generally more structured including how it governs the community although the discussion, in particular, is not mandatory (Kaplan & Haenlein, 2016). Courses in xMOOC can either involve discussion activity as an assignment or part of instruction. In this dimension, this study focuses on investigating how the different settings influence discussion activity in mobile MOOC learning.

6) Community – Division of Labour – Object Dimension

Similar to accessing video lecture, an assumption that learners who are younger, and in college degree are more appealed to participate in a discussion, is made.

Hypothesis 5: Age has a negative effect on forum participation.
Null H5: Age does not have an effect on forum participation.

Hypothesis 6: There is a significant difference between different levels of educational background on forum participation.
Null H6: There is no significant difference between different levels of educational background on forum participation.

4.1.2.6. Iterative Activity-Oriented Design Model (AODM)

An improvisation when incorporating AODM steps with Engeström's activity system model was made during the study. To clearly describe the iterative process of the framework, a workflow model is proposed in Figure 11. As seen in the diagram, the process is primarily derived from Mwanza's AODM methodological tools. If necessary, the hypothesis development stage after generating analytical questions is added depending on the research methodology.

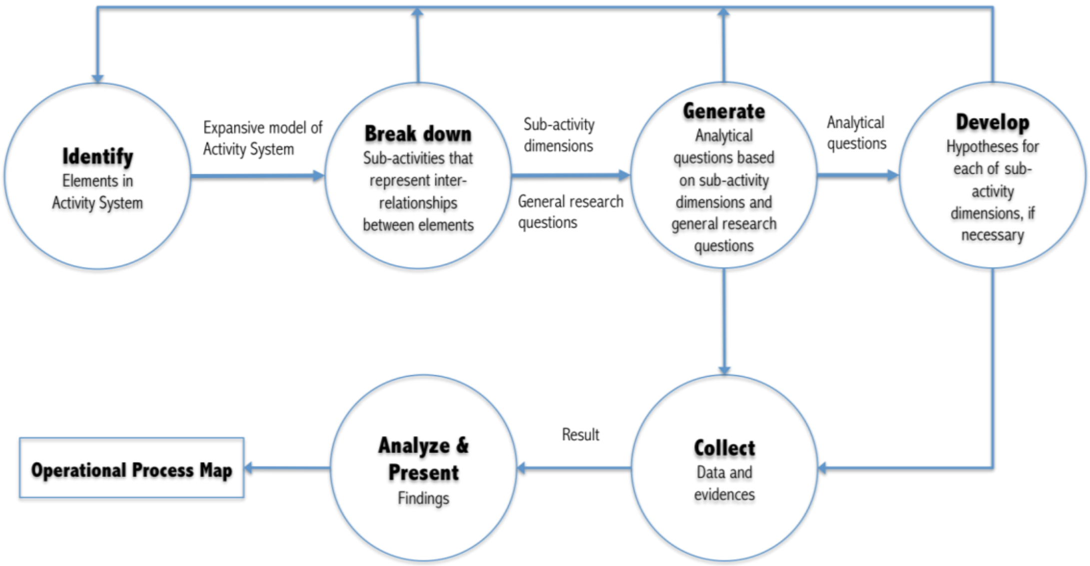

Figure 11. Iterative Process Diagram of Activity Theory-Based Research using AODM

4.2. The Technical Design

4.2.1. Study Design

In regards to the number of contacts with the population of the study, Kumar (2011) classified the design of study into three groups: cross-sectional, before-and-after, and longitudinal. In the case of this study, rather than direct communication with population, contact is an actual point of data collection. Thus, the design of this study is cross-sectional. Kumar (2011) suggested that this design is useful in obtaining an overall 'picture' as it lies at the time of the study. Further, according to Kumar (2011), based on the nature of the investigation perspective, this study is categorised into non-experimental study, as there is neither controlled nor manipulated variables in the process.

4.2.2. Data Collection

With the massive number of learners participated in MOOC, learning analytics has contributed to its development and improvement. There have been a significant number of studies that use big educational data. These studies mainly generated a model of students' learning behaviours concerning their social engagement (Brinton, Chiang, Jain, Lam, Liu, & Wong, 2013) and video interactions (Guo *et al.*, 2014; Kim, Guo, Seaton, Mitros, Gajos, & Miller, 2014; Li, Kidzinski, Jermann, & Dillenbourg, 2015, Stöhr, 2017). These models were then used to analyse demographic and engagement, as well as predict students' dropout and performance (Li *et al.*, 2015).

Similarly, this study also used learning analytics and user interaction data provided by MOOC such as video and discussion interaction to investigate learners' practices when using MOOC on mobile phones. While most of the existing research in MOOC interaction typically considers macro-level activity features such as the number of videos watched and engaging time (Li *et al.*, 2015), this study attempted to take into account click-level activities or clickstream data. In regards to the video interaction, the click-level in-video analysis allows stakeholders to monitor how a student interacts with each of video lectures. For examples, what kinds of actions are employed, when they happen, and how intense they are (Li *et al.*, 2015). Kumar (2011) categorised this type of data into secondary data, meanwhile, the source is called secondary source. The secondary sources for this study as follows:

1) edX Insights: Learning analytics
2) edX LMS (Learning Management System)
3) edX Studio: Tools to build course
4) Event Interaction data provided by Data Specialist

On top of that, it is worth mentioning that there are certain problems with the availability, format, and quality of the data when using secondary sources (Kumar, 2011). The issues concerning the problems with secondary data that might be encountered in the study are outlined below:

1) Validity & reliability
   Since the sources are edX official sites and tools, the data used in the research is valid and reliable to describe and present overall 'picture' of corresponding courses and learners.

2) Personal bias
   This issue might be encountered when using information from personal diaries, newspaper, and magazines since they are naturally subjective and exhibit less rigorousness (Kumar, 2011). Data in the study will be mainly objective as the actual data from edX application is used.

3) Availability of data
   In order to conduct this research, access to edX sites and tools as well as the interaction data as specified above is required. Even then, there are some limitations concerning the attributes or variables to be measured and analysed due to the limitations of the available data itself.

4) Format
   For simplicity factor, necessary format such as age will follow edX Learning Analytics format, e.g. under 25, 25-40, above 40. The same goes for educational background, which is categorised into high school, college, and advanced degree. Gender will be categorised into female and male.

4.2.2.1. Data Pre-Processing

Before processing and analysing the event interaction data, some work to extract and filter the raw data into a useful format is required. The initial format provided by Data Specialist is a JSON[2] file of

[2] JSON (Javascript Object Notation) is a lightweight data-interchange format that is easy for human to write and read and easy for machine to parse and generate (retrieved from https://www.json.org/ at May 9th, 2018)

all the events happening in the application accessed from both browser and mobile in a day. The snippet of the video interaction event taken from edX Research Guide is as follow:


```
{
 "username": "AAAAAAAAAA",
 "event_source": "mobile",
 "name": "edx.video.played",
 "time": "2014-12-09T03:57:24+00:00",
    "agent": "Dalvik/1.6.0 (Linux; U; Android 4.0.2; sdk Build/ICS_MR0)",
    "page":
    "http://courses.edx.org/courses/edX/DemoX/Demo_Course/courseware/d8a6192ade314473a78242dfeedfbf5b/edx_introduction",
    "host": "courses.edx.org",
    "session": "",
    "context": {
      "component": "videoplayer",
         "received_at": "2014-12-09T03:57:56.373000+00:00",
         "course_id": "edX/DemoX/Demo_Course",
         "path": "/segment/event",
         "user_id": 99999999,
         "org_id": "edX",
         "application": {
           "name": "edx.mobileapp.android",
           "version": "0.1.8",
         },
         "client": {
           "network": {
             "wifi": false,
             "carrier": "Android",
             "cellular": true,
             "bluetooth": false
           },
           "locale": "en-US",
           "app": {
             "name": "edX",
             "packageName": "org.edx.mobile",
             "version": "0.1.8",
             "build": "org.edx.mobile@29",
             "versionName": "0.1.8",
             "versionCode": 29
           },
           "library": {
             "version": 203,
             "name": "analytics-android",
             "versionName": "2.0.3"
           },
           "device": {
             "model": "sdk",
             "type": "android",
             "id": "aaa11111aaaa11a1",
             "name": "generic",
             "manufacturer": "unknown"
           },
           "os": {
             "version": "4.0.2",
             "name": "REL",
             "sdk": 14
           },
           "screen": {
             "densityBucket": "xhdpi",
             "density": 2,
             "height": 1184,
             "width": 768,
             "densityDpi": 320,
             "scaledDensity": 2
           }
         }
  },
 "ip": "",
    "event": "{\"code\": \"mobile\", \"id\": \"i4x-edX-DemoX-video-0b9e39477cf34507a7a48f74be381fdd\", \"currentTime\": 114}",
    "event_type": "play_video"
```

```
}
```

By using the JSON event files from 2014 to 2017, a program using Microsoft C# Desktop Application was created to read the files, parse the JSON, and filter by "event_source" and "event_type" for video interaction events. As for discussion events, only "event_type" filter was being used. Afterwards, all the filtered data were stored in a lightweight database using SQLite (See Appendix 1 and 2 for the snippet code of the algorithm). Table 8 specifies supported video interaction and discussion action event types by edX.

Table 8. Video Interaction & Discussion Event Types Supported by edX (edX Research Guide, 2016)

Video Interaction Events	Discussion Action Events
hide_transcript/edx.video.transcript.hidden	edx.forum.comment.created
load_video/edx.video.loaded	edx.forum.response.created
pause_video/edx.video.paused	edx.forum.response.voted
play_video/edx.video.played	edx.forum.searched
seek_video/edx.video.position.changed	edx.forum.thread.created
show_transcript/edx.video.transcript.shown	edx.forum.thread.voted
speed_change_video	edx.forum.thread.viewed
stop_video/edx.video.stopped	
video_hide_cc_menu	
video_show_cc_menu	

4.2.3. Sampling Design

4.2.3.1. Selection of the Courses

The sample of the courses was selected using convenience sampling or non-random sampling strategy. According to Kumar (2011), one of non-random sampling designs that can be applied in the study is quota sampling. In other words, the fundamental consideration of the design is the accessibility to the sample of the population.

This study analysed three courses offered by ChalmersX via edX platform: Graphene Science and Technolgy (ChMOO1x/3T2016) in 2016, Sustainability in Everyday Life (ChMOO2x/3T2016) in 2016, and Master Control in Supply Chain Management and Logistics (ChMOO6x/1T2017) in 2017. The courses were selected based on the availability of the data from 2015 to 2017. Besides, having the mobile app of edX released in 2014, discussion feature was only released in 19 April 2016 for iOS[3] and 11 May 2016 for Android[4]. Thus, more recent iterations were selected to make sure that both video lectures and discussion features are available on the mobile app. Furthermore, the three courses had relatively high enrolment, even though it does not indicate high number of active learners (Niklas & Godhe, 2016). The brief description of courses investigated is outlined as follows:

[3] https://github.com/edx/edx-app-ios/releases/tag/release%2F2.3.0
[4] https://github.com/edx/edx-app-android/releases/tag/release%2F2.3.0-82

1) Graphene Science and Technology (ChMOO1x)
The objective of the course is to develop basic understanding of fundamental characteristics of graphene, the synthesis process and the future applications of graphene. Learners can also develop the competence to perform graphene material synthesis experiment, comprehend scientific articles in graphene research area, identify existing and new areas of graphene application, and more importantly evaluate graphene as career advancement, either academically or industrially. The course is targeting learners who have adequate knowledge of physics and mathematics for university level.

2) Sustainability in Everyday Life (ChMOO2x)
The learning goal of the course is to introduce different aspects of sustainable development concerning chemicals, globalisation, climate change, food, and energy in our everyday life. After the course, learners are expected to be better informed and be able to make a sustainable decision in daily life. ChalmersX offered the course in 2015 for the first time, the second iteration in 2016, and the third had just ended on March 2018. The course is open to anyone who has passed compulsory school for at least nine years and is comfortable using a computer.

3) Master Control in Supply Chain Management and Logistics (ChMOO6x)
The third course being analysed in the study is more specialised than the first and second courses. Even though there is no specific knowledge requirement to join the course, the content of the course is more likely to attract learners from supply chain management and logistics background. During the course, learners will be able to learn about demand management and basic principles; materials management and transportation; procurement, collaboration and risk in supply chains; and digitalization and information systems.

4.2.3.2. Selection of the Sample of the Population

If the population is all the students who use mobile phones to access MOOC, the sample of the study was defined by self-selection sampling. The learners of the courses chose to take part in research concerning MOOC when they gave consent to particular terms and conditions when registering to the platform and the courses. That includes the learners who chose to use mobile phones to access MOOC, whom were selected as the sample of the study. This study defined mobile learner as a learner who at least watched a video lecture via edX mobile app. Meanwhile, this study defined forum participant as a mobile learner who has at least done one of the specified discussion actions. The overview of the population is specified in Table 9 below.

Table 9. Overview of Learners in 3 MOOC Courses

Course	Total Enrolment	Numbers of Mobile Learners	Numbers of Mobile Learners Who Participate in Forum	Number of Passing Learners
ChMOO1x/3T2016	4916	355	17	92
ChMOO2x/3T2016	4610	285	14	50
ChMOO6x/1T2017	8344	730	24	112

4.2.4. Data Analysis

Data was analysed using IBM SPSS Statistics 25. The results were presented in descriptive statistics and visualized by appropriate graphs. Other than that, the hypotheses of the study were validated using Pearson, Point-Biserial, Jonckheere-Terpstra, Kruskall-Wallis H, or independent t-test depending on the type of variables.

4.3. Overview of Data

Table 10 presents overview of the critical figures to be analysed in the three courses. Other than that, this section also specifies data limitations and operationalisation procedure that include variables and component of measurements for the focus of research and hypotheses defined earlier.

Table 10. Overview of Key Figures to be Analysed

Course	Duration in Weeks	Number of Videos	Total Video Length in seconds	Number of Video Interaction Events	Number of Discussion Action Events
ChMOO1x/3T2016	8	64	30291.81	22990	611
ChMOO2x/3T2016	7	50	23027.28	22048	486
ChMOO6x/1T2017	9	47	23023.07	42005	983

4.3.1. Data Limitations

1) Only video interaction logs distinguish events that coming from "browser" and "mobile application". There is no indication of what device used by user for events coming from "browser". Thus, users who use browser from mobile phones are disregarded in this study.

2) Discussion action events do not have the source of event information. Hence in reality, there is no way to identify if a user writes comments from a mobile phone, for instance. However the workaround that is applied in the study is to use the same sample as for video interaction. Therefore, any discussion events coming from a mobile learner are assumed as done through mobile phone.

4.3.2. Operationalisation Procedure

1) Subject – Tool – Object

As the primary activity being analysed in this dimension, each of the video interactions was categorised into three general types: instant complete, progressing complete, drop out or incomplete. Instant complete means that the learner completed the video in one go, while an interaction is considered progressing complete if the learner paused and continued watching in some other time.

It is important to note that edX Insights[5] method of calculating video engagement to consider a video is watched completely was adopted in this study. A complete view is taken place if the learner has reached 30 seconds from the end, or at 95% complete mark. An algorithm to transform raw video event interactions as shown in Section 4.2.2.1 to instant complete and progressing complete actions was developed for this study (See Appendix 3 for the snippet code of the algorithm).

Overall, the component of measurements of each of the video interaction is outlined below:

a) Instant complete
- Percentage of mobile learners who have done instant complete using cellular (mobile) data instead of Wi-Fi.
- Percentage of mobile learners who have done instant complete in specified time intervals. Additionally, I will categorise the time into six different intervals: 08.01 – 12.00, 12.01 – 16.00, 16.01 – 20.00, 20.01 – 24.00, 00.01 – 04.00, and 04.01 – 08.00.

[5] Retrieved from http://edx.readthedocs.io/projects/edx-insights/en/latest/Reference.html#video-engagement-computations on May 13th, 2018

b) Progressing complete
- Percentage of mobile learners who have done progressing complete in at least two different time intervals as specified earlier.
- Percentage of mobile learners who have done progressing complete in at least two different places. This information can be tracked by using IP Address information from the event interaction logs.

It is also important to note that any timestamps recorded in the event log are in UTC. Hence, there is an additional step before calculating any values that are categorised into particular time intervals. In this case, the event timestamps were converted into learners' local time zone.

2) Subject – Rules – Object

The video characteristics that become the main interest were video length and whether a video is followed by quiz or not. A video lecture is considered having a follow-up quiz, if the quiz is part of the same subsection of the video and directly follows the video. The completion rate was measured for each of the video lectures in the course against video length and follow-up quiz variables. The completion rate of a video lecture was measured with the percentage of complete views compared with the total of view attempts including the incomplete views.

3) Subject – Division of Labour – Object

Apart from age, educational background as a measured factor in division of labour element within activity system followed the format in edX Learning Analytics. The educational background was categorised into: high school or less, college, and advanced degree. Learners without formal education, as well as learners who have elementary/primary school, junior secondary/junior high/middle school, and secondary high/school as the highest education, were categorised into high school or less category. College degree was a category for associate and bachelor degree, while master or professional degree and doctorate belong to advanced degree category. The completion rate of a mobile learner was measured with the percentage of video complete views compared with the total numbers of video lectures in the course.

4) Community – Tool – Object

In MOOC, edX in particular, courses that include discussion do not require different registration for joining the forum. It means that each of the learners who enrolled in the course is automatically a member of the forum. However, in regards to the engagement to discussion, the member can be categorised into participant and non-participant. If all mobile learners in the course are forum members, then a mobile learner is regarded as participants if he has conducted at least one of the acknowledged discussion actions. In general, discussion actions that are taken into account are discussion event interaction types from edX as follows: creating a thread, creating a response, creating a comment, viewing a thread, voting a thread, voting a response, and searching forum.

For each of this action, the percentage of discussion event time in the similar time intervals as video interaction was measured. Besides, the percentage of forum participants who have done overall discussion actions in at least two different places was also measured. In this case, IP Address information in the event log was used.

5) Community – Rules – Object

Generally, discussion action is categorised into active and passive participation. Active participation means that the learner is actually engaged in discussion by sharing questions or thoughts, while a learner participates passively by reading or giving responses, such as 'like' or 'vote'. Therefore, event type "edx.forum.thread.created", "edx.forum.response.created", and "edx.forum.comment.created" for edX event log data are considered active participation. While, passive participation includes "edx.forum.thread.viewed", "edx.forum.thread.voted", "edx.forum.response.voted", and "edx.forum.searched".

Further, the three selected courses had different settings regarding discussion action in the community. ChMOO1x, for instance, included discussion in the weekly instruction and creates dedicated discussion topic for each module. ChMOO2x put discussion as one of the assignments in the course, while ChMOO6x was the least demanding when it comes to discussion. Finally, the active and passive participation percentage for the three different settings was calculated.

6) Community – Division of Labour – Object

Similar to subject – division of labour – object dimension, this dimension also takes into account forum participants' age and educational background. The difference lies in the component of measurement in which the number of discussion actions done by each of the participants is calculated.

4.3.3. Variables, Data Types, and Correlations

This section specifically defines all the variables involved for each of the sub-activity dimensions as mentioned in earlier section (See Table 7). Symbol 'I' in the variable list indicates independent variable, whereas 'D' is given to the dependent variables. Additionally, several data types are used for the variables listed in Table 11 below.

According to Laerd Statistics[6], nominal variables consist of two or more categories yet are not intrinsically ordered. While variables that contain exactly two categories, for example female and male, are called dichotomous. The nominal variables that can be ordered or ranked are defined as ordinal. Last but not the least is continuous variables that are also known as quantitative or numeric variables.

Subsequently, different correlation procedures were applied depending on the data type of the variables. Taken from Laerd Statistics, Pearson Correlation[7] is typically used for two continuous variables. In addition, a correlation between a dichotomous variable and continuous dependent variable can use Point-Biserial[8] correlation. In this study, Independent t-test was used to overcome violation of homogeneity of variances in Point-Biserial correlation test. The independent t-test is an inferential statistical test to determine statistically significant difference between the means in two unrelated groups.

Lastly Jonckheere-Terpstra[9] is recommended for determining significant statistic trend between an ordinal independent variable with an ordinal or continuous dependent variable. Alternatively, Kruskall-Wallis H[10] test can be performed if any of the assumptions in Jonckheere-Terpstra test are violated.

[6] Retrieved from https://statistics.laerd.com/statistical-guides/types-of-variable.php on July 16th, 2018
[7] Retrieved from https://statistics.laerd.com/spss-tutorials/pearsons-product-moment-correlation-using-spss-statistics.php on July 16th, 2018
[8] Retrieved from https://statistics.laerd.com/spss-tutorials/point-biserial-correlation-using-spss-statistics.php on July 16th, 2018
[9] Retrieved from https://statistics.laerd.com/spss-tutorials/jonckheere-terpstra-test-using-spss-statistics.php on July 16th, 2018
[10] Retrieved from https://statistics.laerd.com/spss-tutorials/kruskal-wallis-h-test-using-spss-statistics.php on September 20th, 2018

Table 11. Information of Measured Variables in Sub-activity Dimensions

Sub-activity Dimension	**Variables**		**Data Type**	**Correlations**
Subject – Tools – Object	I*	Network	Dichotomous	
	I	Time Intervals	Nominal	
	D**	Instant Complete Action Rate (%)	Continuous	
	I	Number of Time Intervals	Ordinal	
	I	Number of Places	Ordinal	
	D	Progressing Complete Action Rate (%)	Continuous	
Subject – Rules – Object	I	Video Length (s)	Continuous	Pearson
	I	Follow-up Quiz	Dichotomous	Point-Biserial, Independent t-test
	D	Video Completion Rate (%)	Continuous	
Subject – Division of Labour – Object	I	Age	Continuous	Pearson
	I	Education	Ordinal	Jonckheere-Terpstra
	D	Video Completion Rate (%)	Continuous	
Community – Tools – Object	I	Time Intervals	Nominal	
	D	Forum Participation Rate (%)	Continuous	
	I	Places	Dichotomous	
	D	Forum Participants (%)	Continuous	
Community – Rules – Object	I	Participation Type	Dichotomous	
	D	Forum Participation (%)	Continuous	
Community – Division of Labour – Object	I	Age	Continuous	Pearson
	I	Education	Ordinal (Nominal)	Jonckheere-Terpstra, Kruskall-Wallis H
	D	Numbers of Forum Participation	Continuous	

*. I: Independent variable
**. D: Dependent variable

4.4. Ethical Consideration

edX as the MOOC provider and the secondary sources of this research has adopted an amended Privacy Policy since 2014 and has recently updated the policy on May 15th, 2018[11]. According to the article, when users register to the site, they consent to the collection, use, disclosure, and retention by edX of their personal information as described in the Privacy Policy. The consent is including but not limited to the sharing of their personal data between edX and third parties, affiliates, and subsidiaries in the Privacy Policy. Additionally, edX specifies multiple purposes of using personal information that also grants the purpose of this study, supporting scientific research in the areas of cognitive science and education. Nevertheless, as a third party who uses users' personal information, this study respects and maintains the confidentiality of information and anonymity of the users. The users' personal information will not be exposed at any means in this research. Furthermore, the transfer of data from the affiliate, in this case, ChalmersX Data Specialist is done through a portable hard disk. Thus there is no data floating around in the cloud.

[11] https://www.edx.org/edx-privacy-policy

5. Results

In this section, the first result to be presented concerns the conceptual analysis of MOOC format in the perspective of mobile learning. First, course target learners, course demographics in general, and conceptual analysis of MOOC format are presented. Furthermore, learners' practices pattern is described and discussed based on sub-activity notation (dimension) in the activity system. Several metrics are analysed to accept or reject the established hypotheses. Finally, the results are used to answer the given research questions.

5.1. MOOC in Perspective of Mobile Learning

5.1.1. Course Target Learners

Since the courses analysed in the study are coming from three different fields, the target learners for the courses are also different. However, there are few underlining specifications for the learners to consider before registering to the course to fully engage. Table 12 below gives the idea of learner profiles that were targeted by the courses.

Table 12. The Target Learners of the Course

Course	Target Learners
ChMOO1x/3T2016	• Have adequate knowledge of general physics and university level mathematics • Time commitment of 6 hours per week, 48 hours in total
ChMOO2x/3T2016	• Passed compulsory school of at least 9 years • Time commitment of 6 hours per week, 42 hours in total
ChMOO6x/1T2017	• Higher education students or Professionals • Have general understanding of low level programming computers

5.1.2. Course Demographics

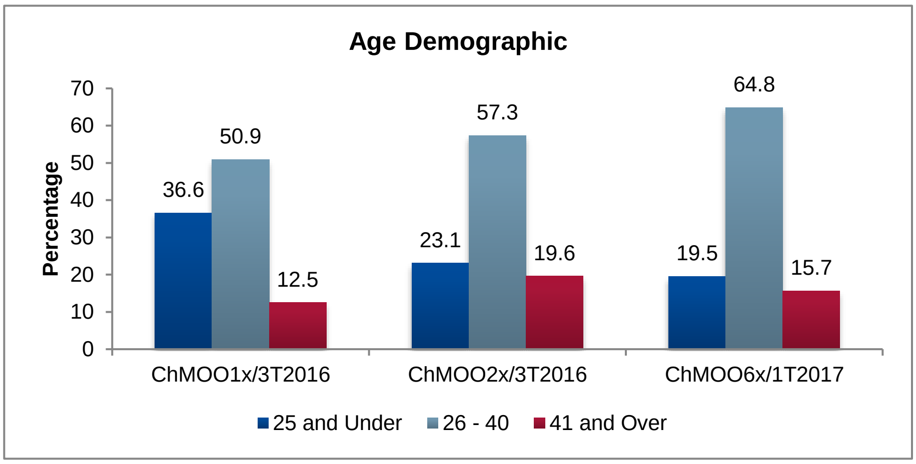

Figure 12. Enrolled Learners Distributions by Age for All Courses

The age demographic in Figure 12 above shows that the three courses had something in common in which the majority of the enrolled learners were between 26 and 40 years old. Looking at the median value of the age distribution, ChMOO1x had the lowest median with 27 years old, while ChMOO2x and ChMOO6x had higher median value with 31 and 30 years old respectively. The demographic figure shows that ChMOO1x course in the field of science attracted younger learners, which is also portrayed by its highest percentage of learners in the age of 25 years old and under.

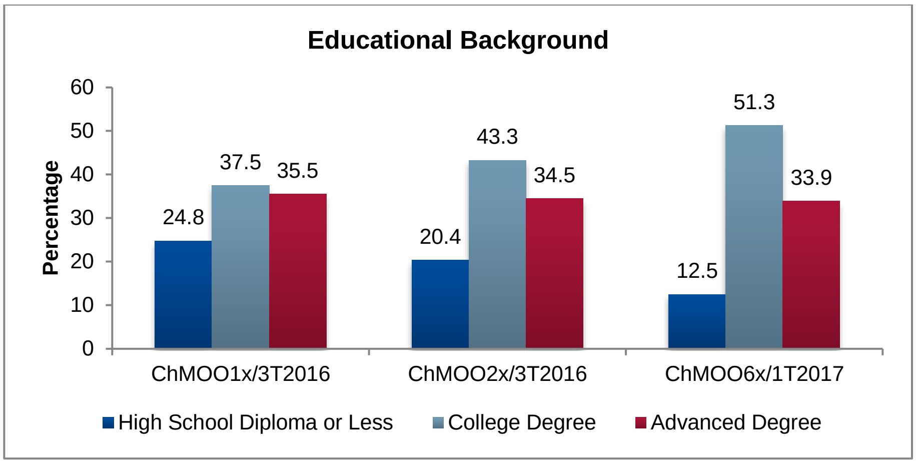

Figure 13. Enrolled Learners Distributions by Educational Background for All Courses

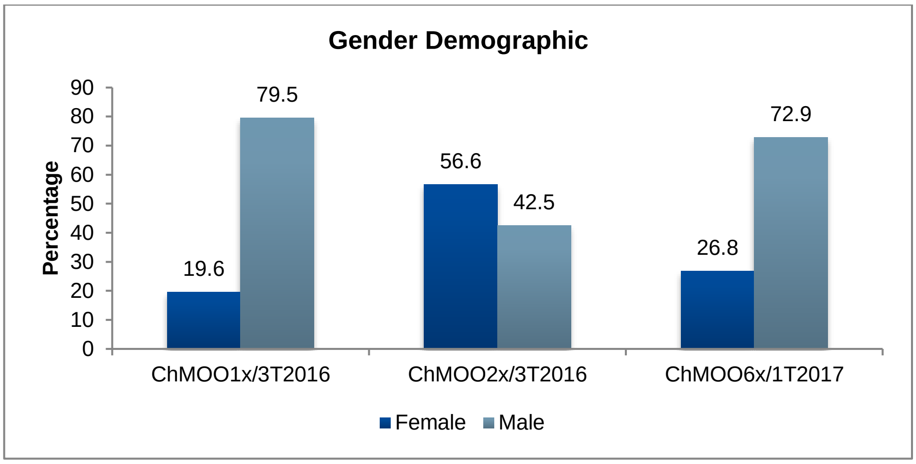

Figure 14. Enrolled Learners Distributions by Gender for All Courses

As for the educational background, the majority of the enrolled learners had a college degree as their educational background with a reasonably small percentage gap with the advanced degree. The highest difference was found in ChMOO6x course that aimed at higher education students or professionals explicitly. How target learners' criteria could affect the educational background demographic is also supported by the fact that ChMOO6x course had the lowest percentage of 'high school diploma or less' category. Interesting enough, ChMOO1x and ChMOO6x courses attracted more males compared to females, in contrast with ChMOO2x course that attracted more females with 14% higher percentage compared to males. As apparent from age and educational background demographic figures, it is safe to say that most learners were young to adult range of ages and in college to advanced degree. Interestingly, the gender characteristic could not be generalised based on the data from the three courses. Both ChMOO1x and ChMOO6x courses were highly male dominant, while ChMOO2x course attracted more female learners.

5.1.3. Course Format

In order to examine MOOC format that enables mobile learning practice, the format of the three selected courses were reviewed with Sharples *et al.*'s mobile learning criteria as specified in Section 4.1.1. Table 13 below shows the extensive comparison of the three selected courses' format relevant to the mobile learning criteria defined by Sharples *et al.* (2006). Following Engeström's expansive model, two perspectives of tool-mediated activity are presented. Other than the semiotic layer from Engeström's activity model, Sharples *et al.* (2006) proposed a technological layer. The semiotic layer represents cultural rules, community, and division of labour, while control, context, and communication elements are specified for technological layer. Based on this concept, firstly, the activity components from semiotic and technological layers were associated to each of the criteria. As an example, rules and control were deemed as appropriate components to describe learning settings in MOOC that make them different from classroom, workplace, or lifelong learning. Then, the course format and characteristics that correspond with the components were mapped. The same steps were done for other criteria.

Overall, the criteria that need to be satisfied are concerning the difference in course setting between MOOC and classroom, workplace, or lifelong learning, then the mobility of learners, informal and formal learning, constructive and social process, as well as personal and situated activity mediated by technology. As specified in Table 13, the prominent distinct characteristics of MOOC are in its rules and control aspects. Generally speaking, both MOOC and classroom or workplace learning have a curriculum that consists of different modules, assignments, and a kind of completion reward. In a formal school, the completion reward is typically a “pass” to next grade or level. Meanwhile, in workplace, similar to MOOC, the common reward would be getting a completion certificate, though getting a salary raise or job promotion is still applicable. Unlike classroom system where a “pass” or “graduate” is a requirement to continue to the next grade, in MOOC, learners do not have to complete a course to enrol in another course. Unless a case where an advanced course has basic course as prerequisite. A close classroom setting that can be found in MOOC is instructor-paced where the course syllabus follows a schedule that has been set by instructor. This pace is used by ChMOO1x and ChMOO6x courses. Similar to classroom situation, learners have to complete assignments and exams in specific due dates. Another setting that is common in online learning, yet unique if compared to classroom learning, is self-paced. Learners can progress at their speed and there is no due date for assignments.

Courses in MOOC are generally supporting mobility characteristic of mobile learning. Despite the different perspectives in defining “mobile”, one could agree that MOOC is accessible whenever and wherever the learners need it. The video lectures can be watched at any times when the learners are comfortable the most. In addition, MOOC is now available in mobile application. Hence, technically, learners can access the course the same way they use messaging or social media anytime and anywhere. Importantly, learners do not have to be physically together at the same time and place to engage with the course and other learners. They can also ask things and engage in discussions whenever they want. When it comes to rules, the instructor-paced courses resemble formal learning with more organized and structured syllabus while self-paced lean towards informal learning with more freedom and flexibility including enrolment period. MOOC also offers a community where learners can share knowledge and experience with each other that can be a valuable source of learning.

Additionally, community and two-way communication between instructor and learners as well as between learners, support the learning practice as a social process. A concrete example is peer assessment in ChMOO2x course that motivates learners to share constructive feedback and enhance social engagement. The other distinct features of MOOC that satisfy Sharples *et al.*’s mobile learning criteria are personalisation and its dependency with technology. All in all, the study found that five criteria of mobile learning by Sharples *et al.* (2006) are satisfied by MOOC format and components, particularly ChMOO1x, ChMOO2x, and ChMOO6x courses. More details on the activity components and its corresponding MOOC settings are specified in Table 13 below.

Table 13. MOOC Format Comparison Using Sharples et al.'s Mobile Learning Criteria

Criteria	**Activity Components**	**ChMOO1x**	**ChMOO2x**	**ChMOO6x**
Is it significantly different from current theories of classroom, workplace or lifelong learning?	Rules	**Schedule:** - The course consists of seven weekly modules, each of new module is released every week - The learners can watch video lectures anytime, anywhere	**Schedule:** - The course consists of six weekly modules, each of new module is released every week - The learners can watch video lectures anytime, anywhere	**Schedule:** - The course consists of four weekly modules, each of new module is released every week - The learners can watch video lectures anytime, anywhere
		Assessment: - Weekly quizzes and assignments - Weekly assignments 60%; Final assignments 40% - Two attempts for answering quizzes	**Assessment:** - Weekly quizzes & exercises, peer assessments, and discussions - Introductory hotspot quizzes: 20%; Mini-lecture Assignments: 40%; Final Exam: 40% - Two attempts for answering quizzes	**Assessment:** - Weekly quizzes & exercises, assessments - Assignments: 50%; Final Exam: 50% - Two attempts for answering quizzes
		Certificate: - Passing grade 60% - Every assignment needs to be submitted within 2 weeks after publication	**Certificate:** - Passing grade 60% - Assignments need to be submitted before the end of the course	**Certificate:** - Passing grade 60% - Assignments need to be submitted before a specified date
		Instructor-paced: - The course syllabus follows a schedule that the instructor sets - The assignments and exams have specific due dates	**Self-paced:** - The learners can progress through the course at their own speed - The assignments do not have due dates	**Instructor-paced:** - The course syllabus follows a schedule that the instructor sets - The assignments and exams have specific due dates
	Control	- Learners have full control of choosing the technology to use - Learners have full and flexible access to the learning sources - Learners are independent in operating learning tools	- Learners have full control of choosing the technology to use - Learners have full and flexible access to the learning sources - Learners are independent in operating learning tools	- Learners have full control of choosing the technology to use - Learners have full and flexible access to the learning sources - Learners are independent in operating learning tools

Does it account for the mobility of learners?	Context	**Mobility:** - Video lectures can be watched anytime and anywhere - Learners do not have to be physically together at the same time and in the same place to engage with the course	**Mobility:** - Video lectures can be watched anytime and anywhere - Learners do not have to be physically together at the same time and in the same place to engage with the course	**Mobility:** - Video lectures can be watched anytime and anywhere - Learners do not have to be physically together at the same time and in the same place to engage with the course
	Control	- The course can be accessed through desktop computer, laptop, and mobile devices such as mobile phone and tablet	- The course can be accessed through desktop computer, laptop, and mobile devices such as mobile phone and tablet	- The course can be accessed through desktop computer, laptop, and mobile devices such as mobile phone and tablet
Does it cover both formal and informal learning?	Rules	**Instructor-paced**: organised and structured syllabus leading to formal learning, has specific enrolment dates	**Self-paced**: more flexibility and freedom in engaging with the course leading to informal learning, can enrol anytime	**Instructor-paced**: organised and structured syllabus leading to formal learning, has specific enrolment dates
	Division of Labour	- Two-way relationship between instructor and learner - Open for big range of ages and educational levels	- Two-way relationship between instructor and learner - Open for big range of ages and educational levels	- Two-way relationship between instructor and learner - Open for big range of ages and educational levels
	Community	Community and the discussion activity allow learners to learn informally from other learners' knowledge and experiences	Community and the discussion activity allow learners to learn informally from other learners' knowledge and experiences	Community and the discussion activity allow learners to learn informally from other learners' knowledge and experiences
Does it theorise learning as a constructive and social process?	Rules	- Two attempts are given to answer quizzes so that learners can learn from mistake	- Two attempts are given to answer quizzes so that learners can learn from mistake - Peer assessment as a part of constructive and social process	- Two attempts are given to answer quizzes so that learners can learn from mistake
	Community	The course includes discussion in the weekly instruction and creates dedicated discussion topic for each module	The course puts discussion as one of the assignments in the course	Discussion as part of the course in voluntarily manner
	Communication	Two-way communication between instructor and learner, learner can ask questions to instructor	Two-way communication between instructor and learner, learner can ask questions to instructor	Two-way communication between instructor and learner, learner can ask questions to instructor

Does it analyse learning as a personal and situated activity mediated by technology?	Rules	- The video in each module can be watched in personalised manner, anytime, and anywhere	- The video in each module can be watched in personalised manner, anytime, and anywhere	- The video in each module can be watched in personalised manner, anytime, and anywhere
	Control	- The learners need to use technology such as computer or mobile device in order to participate in the course	- The learners need to use technology such as computer or mobile device in order to participate in the course	- The learners need to use technology such as computer or mobile device in order to participate in the course
	Context	- Learners are in their personal space when learning (even though they are in public place) - Learners can directly try or implement what they learn through video lectures or discussion without time and place constraint	- Learners are in their personal space when learning (even though they are in public place) - Learners can directly try or implement what they learn through video lectures or discussion without time and place constraint	- Learners are in their personal space when learning (even though they are in public place) - Learners can directly try or implement what they learn through video lectures or discussion without time and place constraint
	Community	- Learners can have discussion with other learners or instructors virtually through technology	- Learners can have discussion with other learners or instructors virtually through technology	- Learners can have discussion with other learners or instructors virtually through technology
	Communication	- Not a face-to-face communication - Communication is done through technology such as computer or mobile phone	- Not a face-to-face communication - Communication is done through technology such as computer or mobile phone	- Not a face-to-face communication - Communication is done through technology such as computer or mobile phone

5.2. The Pattern of Learners' Practices in MOOC on Mobile Phone

5.2.1. Subject – Tools – Object

The first dimension of activity system presented in the results section is regarding subject, tools, and object relationship. Firstly, the number of mobile learners was defined from the overall video lectures in the course and does not mean that all learners are being active by watching each of the video lectures. By using the number of active learners, the active rate of a video was measured by the percentage of the active learners compared with the number of mobile learners of the course. Table 14 below shows the active rate for each of the courses. The active rate can be seen as an indicator to the proportion of how many learners are actually engaging with the course in terms of watching video lectures. See Appendix 4 for the example of active learners and active rate per video lecture data.

Table 14. Overview of the Active Rate (%) for All Courses

Course	Number of Mobile Learners	Number of Video Lectures	Active Rate (%)		
			Max	Min	Avg
ChMOO1x	355	64	49.30	1.13	8.55
ChMOO2x	285	50	61.05	1.75	10.00
ChMOO6x	730	47	60.27	1.10	7.79

There are three different actions defined in the study to be considered as an interaction with video lectures: incomplete means that a learner does not complete the video, instant complete defines a learner who completes a video lecture in one go, and progressing complete, which means that a learner has several time gaps before finally completing the video. The typical pattern of progressing complete action are playing the video, pause, and then play again after some time, until the video is completed. Figure 15 shows the distribution of the total numbers of active learners per video by the video actions specified earlier. Meanwhile, Figure 16 shows the distribution of average numbers of the active rate by video actions. For instance, incomplete rate (%) of a video was measured with the percentage of active learners with incomplete views compared with the number of active learners in a video lecture. The same formula was applied for instant complete and progressing complete actions.

Both Figure 15 and Figure 16 establish different patterns for the three courses. In ChMOO1x course, the total numbers of active learners who have done incomplete views are the highest, followed by progressing complete and instant complete views with a minimal gap. However, the distribution of average numbers of active rate figure shows that progressing complete action rate is 1% higher than the incomplete rate. Differently, the figure for ChMOO2x course shows that the total numbers of active learners with progressing complete views are the highest, followed by incomplete and instant complete views. Correspondingly, the active rate distribution figure shows a similar trend with the average number of progressing complete rate being the highest while the average number of instant complete rate is significantly lower. Another different trend is showcased by ChMOO6x course where the total numbers of incomplete views, as well as the average number of incomplete rate, are being the highest. However, a consistent trend between instant complete and progressing complete action is still found with the latter being higher than the former.

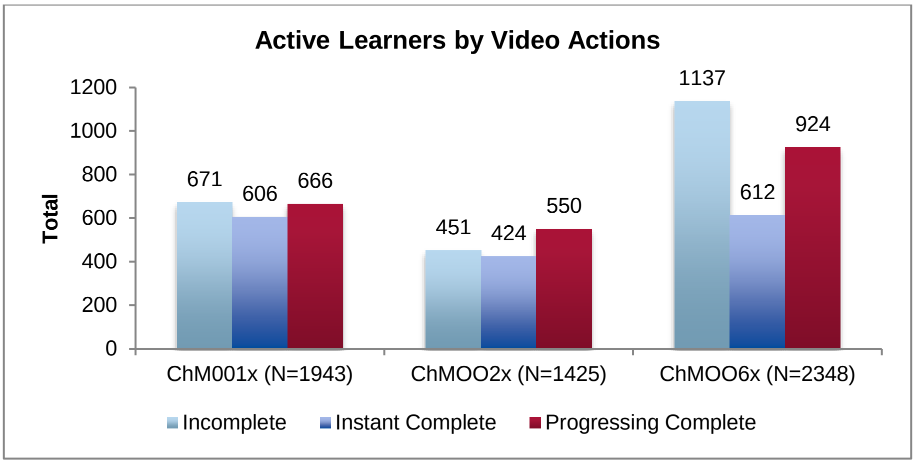

Figure 15. Active Learner Distributions by Video Action for All Courses

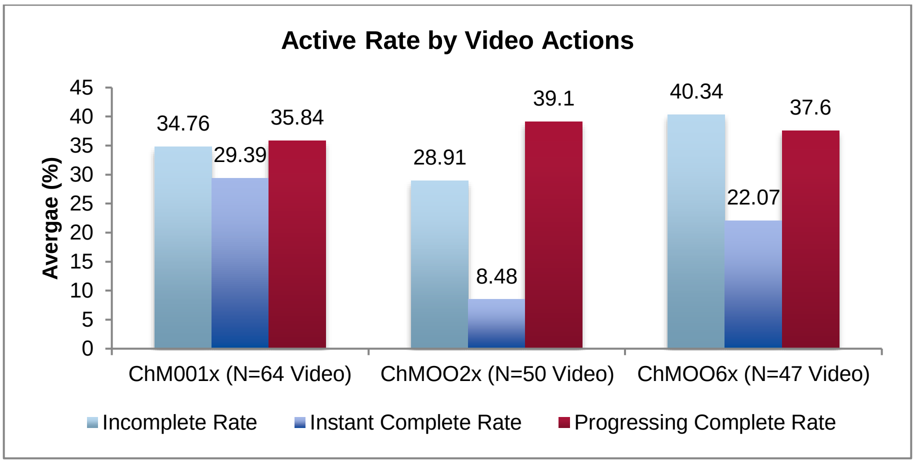

Figure 16. Average Active Rate by Video Actions for All Courses

As the result of breaking down the instant complete action finding, Figure 17 and Figure 18 show the average number of instant complete views by two different dimensions, network and time interval. The network dimension was used to categorise learners who completed a video using Wi-Fi and cellular data from their mobile phones. As shown in Figure 17, the majority of learners were still dependent on Wi-Fi coverage to watch video lectures in the three courses. Regarding cellular data usage, ChMOO6x course has the highest percentage of learners that completed video lectures with 30.99%, followed by ChMOO2x with 28.77% and ChMOO1x being the lowest with the portion less than 15%. Next, the percentage of learners with instant complete views was also calculated by time dimension that was classified into six-time intervals. Figure 18 shows that for both ChMOO2x and ChMOO6x courses more than 40% of the learners completed the video lectures between 16.00 and 24.00. In contrast, 36.38% of the learners in ChMOO1x course completed the video lectures between 08.00 and 16.00. Overall, ChMOO1x course has the most homogeneous distribution between time intervals. For the example of the details on instant complete action rate see Appendix 5.

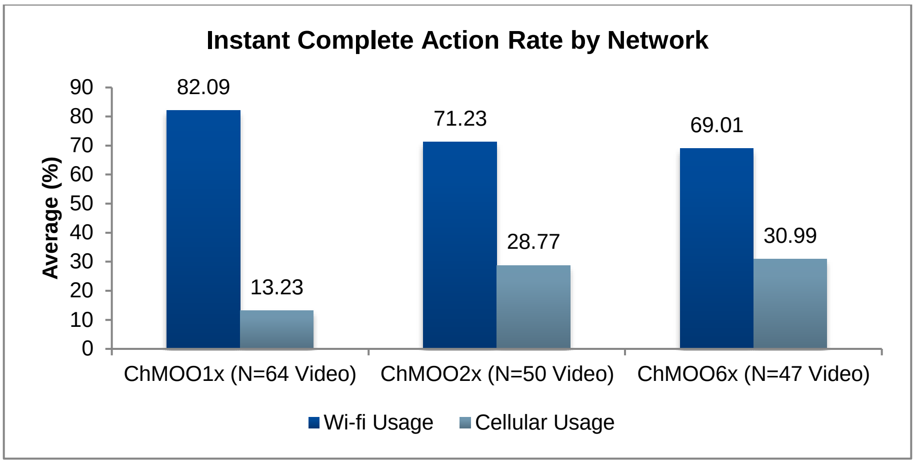

Figure 17. Average Instant Complete Action Rate by Network for All Courses

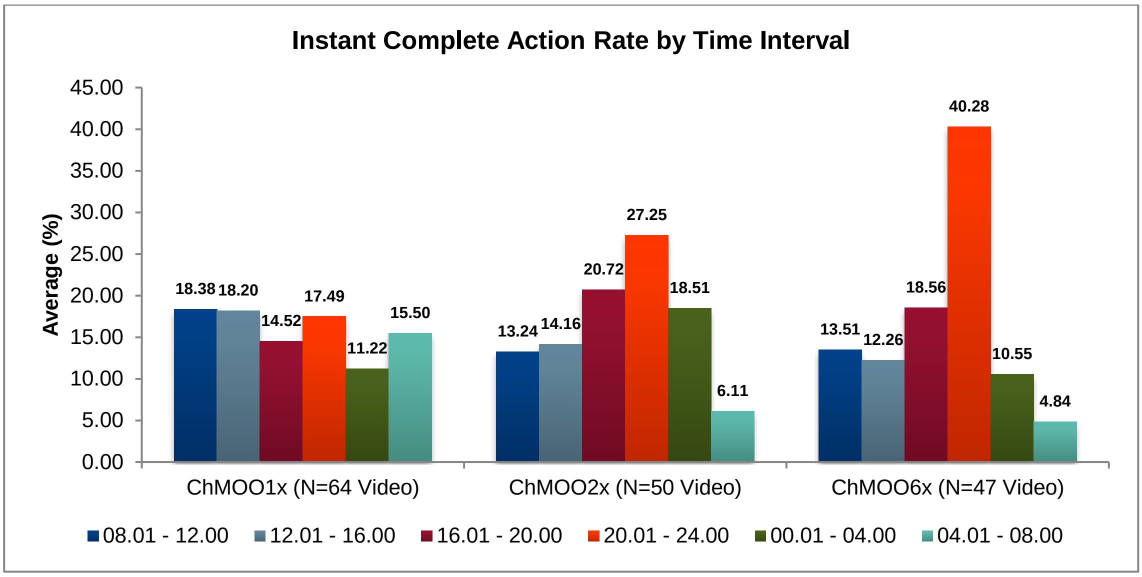

Figure 18. Average Instant Complete Action Rate by Time Interval for All Courses

Other than that, the study looked into two dimensions, time and place, to elaborate the findings in progressing complete action. Different from the instant complete action where the specific time interval is defined, for progressing complete, there is a possibility that the actions are done in multiple time intervals. Hence, the number of time intervals recorded when a learner is progressively watching a video lecture was calculated. Figure 19 shows that more than 50% of the learners gradually completed the video lecture within a time interval in ChMOO2x and ChMOO6x courses, while interestingly progressing complete action rate for multiple time intervals is higher in ChMOO1x course with percentage 54.51% in total. In addition, the percentage of learners with progressing complete views done in the specified number of places was also calculated. Correspondingly, the result as shown in Figure 20 has a similar trend with the time dimension result. Leading by a tiny gap, ChMOO1x course had progressing complete action rate in multiple places with 50,46%. In contrast, the majority of learners in ChMOO2x and ChMOO6x courses still completed video lectures in one place with percentage 56.02% and 65.29% respectively. The example of detailed progressing complete action rate data can be found in Appendix 6.

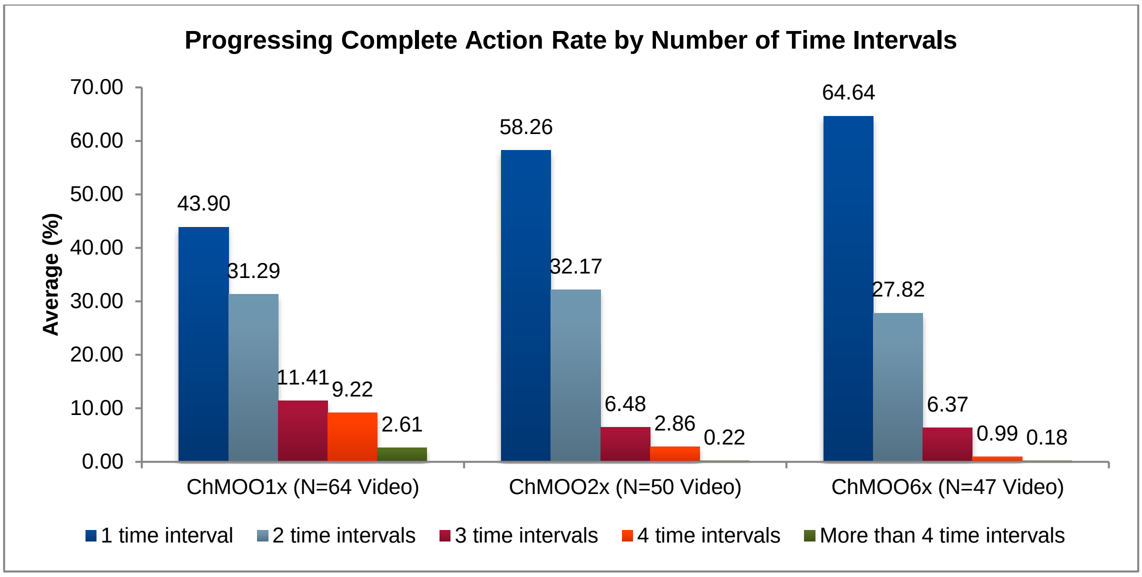

Figure 19. Average Progressing Complete Action Rate by Number of Time Intervals for All Courses

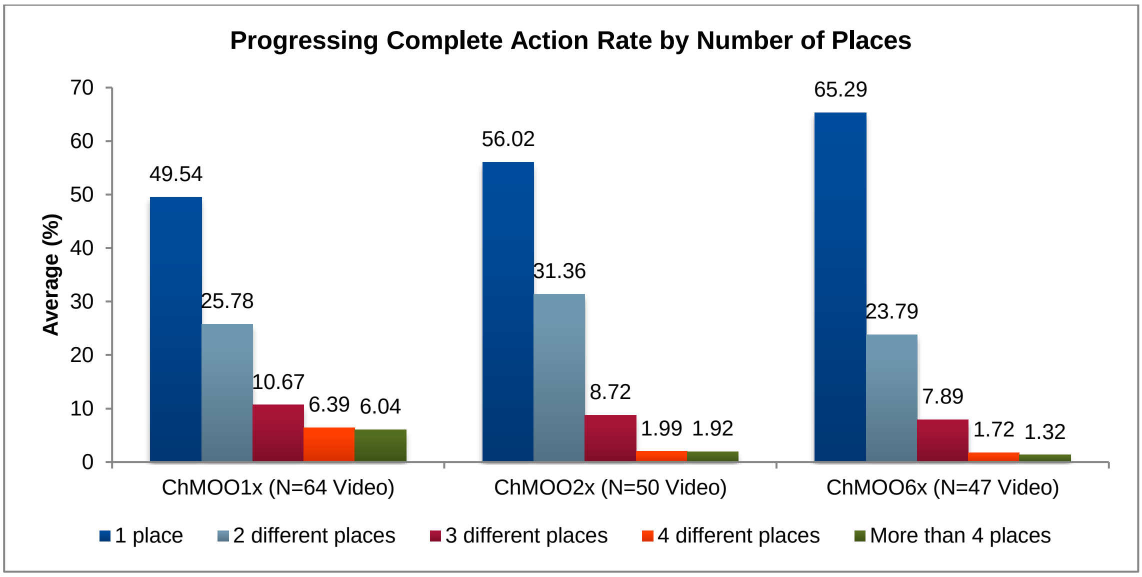

Figure 20. Average Progressing Complete Action Rate by Number of Places for All Courses

5.2.2. Subject – Rules – Object

There are two different independent variables analysed in Subject – Rules – Object dimension of activity system, video length, and follow-up quiz (The example of detailed data can be seen in Appendix 7). Firstly, Pearson Correlation in SPSS was computed against the three selected courses to assess the relationship between video length and video completion rate. As shown in Table 15, there was a negative correlation between video length and video completion rate that was statistically significant in ChMOO1x course ($r = -.440$, $n = 64$, $p = .000$); ChMOO2x course ($r = -.352$, $n = 50$, $p = .012$); and ChMOO6x course ($r = -.364$, $n = 47$, $p = .012$). Overall, this result strengthened Hypothesis 1 that video length has a negative effect on video completion rate where the increases in video length were correlated with the decreases in video completion rate.

Table 15. Correlations of Video Completion Rate with Video Length and Follow-up Quiz on Full Size Samples

Course			**Video Length (s)**	**Follow-up Quiz**
ChMOO1x	Video Completion Rate	Pearson Correlation	-.440**	
		Sig. (2-tailed)	.000	
		Point-Biserial Correlation		*Not applicable*
		Sig. (2-tailed)		*Not applicable*
		N	64	64
ChMOO2x	Video Completion Rate	Pearson Correlation	-.352*	
		Sig. (2-tailed)	.012	
		Point-Biserial Correlation		*Not applicable*
		Sig. (2-tailed)		*Not applicable*
		N	50	50
ChMOO6x	Video Completion Rate	Pearson Correlation	-.364*	
		Sig. (2-tailed)	.012	
		Point-Biserial Correlation		*Not applicable*
		Sig. (2-tailed)		*Not applicable*
		N	47	47

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Additionally, Point-Biserial Correlation was conducted to assess the correlation between follow-up quiz and video completion rate. The results in Table 15 show that Point-Biserial Correlation was not applicable for the full size samples of the three selected courses. The sample in ChMOO1x course violated the assumption of homogeneity of variances (F(1.62) = 5.511, p = .022), while the other two courses violated the assumption that there should be no outliers for the continuous variable for each category of the dichotomous variable (Assumptions testing is provided in Appendix 8). In particular, independent t-test for two samples can be computed to overcome violation of homogeneity of variances. As shown in Table 16, particularly when equal variances not assumed, there were no statistically significant differences between means on the variables of follow-up quiz and completion rate in ChMOO1x course as the *p*-value is greater than 0.05 (t(40.571) = .471, p = .640).

Table 16. Independent t-test of Unequal Variances on Follow-up Quiz and Video Completion Rate in ChMOO1x Course

		Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F	5.511	
	Sig.	.022	
t-test for Equality of Means	t		.471
	df		40.571
	Sig. (2-tailed)		.640

*. Differences between means are significant at the 0.05 level (2-tailed)

After eliminating outliers in both ChMOO2x and ChMOO6x courses, Point-Biserial Correlation was run to determine the correlation between the variables of follow-up quiz and completion rate (See Table 17). Similar to ChMOO1x course, there was no correlation between the two variables in ChMOO2x course (r_{pb} = .250, n = 49, p = .083). In contrast, the correlation between follow-up quiz and completion rate in ChMOO6x course was statistically significant (r_{pb} = .308, n = 46, p = .019). Nevertheless, the result is insufficient to accept Hypothesis 2 that follow-up quiz has an effect on video completion rate, thus its null hypothesis that follow-up quiz does not have an effect on video completion rate was retained.

Table 17. Correlations of Video Completion Rate with Follow-up Quiz on Samples without Outliers (Normally Distributed)

Course			**Follow-up Quiz**
ChMOO2x	Video Completion Rate	Point-Biserial Correlation	.250
		Sig. (2-tailed)	.083
		N	49
ChMOO6x	Video Completion Rate	Point-Biserial Correlation	.308*
		Sig. (2-tailed)	.019
		N	46

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

5.2.3. Subject – Division of Labour – Object

Pearson Correlation was computed to determine whether there is correlation between mobile learners' age and video completion rate. As displayed in Table 18, there was no correlation between mobile learners' age and video completion rate for all courses with the following statistical result: ChMOO1x course (r = .110, n = 240, p = .090); ChMOO2x course (r = .110, n = 161, p = .167); and ChMOO6x course (r = .049, n = 450, p = .303). Having said that, Hypothesis 3 where age has a negative effect on video completion rate was not accepted and its null hypothesis that age does not have an effect on video completion rate was retained.

Table 18. Correlations of Video Completion Rate with Mobile Learners' Age

Course			**Age**
ChMOO1x	Video Completion Rate	Pearson Correlation	.110
		Sig. (2-tailed)	.090
		N	240
ChMOO2x	Video Completion Rate	Pearson Correlation	.110
		Sig. (2-tailed)	.167
		N	161
ChMOO6x	Video Completion Rate	Pearson Correlation	.049
		Sig. (2-tailed)	.303
		N	450

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Furthermore, Jonckheere-Terpstra test was run to determine if there is statistically significant trend between educational background and video completion rate. As summarized in Table 19 and its details in Table 20, a Jonckheere-Terpstra test for ordered alternatives showed that there was a statistically significant trend of higher median video completion rate with higher levels of educational background for ChMOO1x course (from "high school diploma or less", "college degree" to "advanced degree" educational background), T_{JT} = 10030.500, z = 2.088, p = .037. Different result was showcased by ChMOO2x and ChMOO6x courses in which there was no statistically significant trend of higher median video completion rate with higher levels of educational background: ChMOO2x course (T_{JT} = 4017.500, z = .193, p = .847); ChMOO6x course (T_{JT} = 25072.500, z =-.840, p = .401). Hence, the alternative Hypothesis 4 that there is a significant difference between different levels of educational background on video completion rate cannot be accepted and its null hypothesis that there is no significant difference between different levels of educational background on video completion rate was retained.

Table 19. Differences on Video Completion Rate between Mobile Learners' Educational Backgrounds

Hypothesis Test Summary				
Null hypothesis	**Test**	**Course**	**Sig.**	**Decision**
The distribution of Video Completion Rate is the same across categories of Educational Background	Independent-Samples Jonckheere-Terpstra Test for Ordered Alternatives	ChMOO1x	.037*	Reject the null hypothesis
		ChMOO2x	.847	Retain the null hypothesis
		ChMOO6x	.401	Retain the null hypothesis

*. Difference is significant at the 0.05 level

Table 20. Details of Differences on Video Completion Rate between Mobile Learners' Educational Backgrounds

Hypothesis Test Details			
	ChMOO1x	**ChMOO2x**	**ChMOO6x**
Total N	232	158	424
Test Statistic	10030.500	4017.500	25072.500
Standard Error	541.698	298.601	1255.568
Standardized Test Statistic	2.088	.193	-.840
Asymptotic Sig. (2-sided test)	.037	.847	.401

As mentioned earlier, the highest median video completion rate was found in advanced degree group (n = 81, M = 3.13), followed by college degree (n = 87, M = 1.56) and high school (n = 64, M = 1.56) group respectively for ChMOO1x course. In contrast, since there was no statistically significant trend of median found in both ChMOO2x and ChMOO6x courses, mean value was identified. In ChMOO2x course, highest mean video completion rate was found in advanced degree group (n = 54, μ = 10.07), followed by high school group (n = 32, μ = 7.25), and college degree group (n = 72, μ = 6.25). As for ChMOO6x course, highest mean video completion rate was found in college degree group (n = 231, μ = 5.20), followed by advanced degree (n = 137, μ = 4.83), and high school group (n = 56, μ = 3.23).

5.2.4. Community – Tools – Object

Overall, there are two parameters analysed in Community – Tools – Object dimension of an activity system, time intervals in which the discussion actions are done within community and number of places wherein the forum participants conducted overall discussion actions. The forum participants could perform the following discussion actions: creating a thread, creating a response, creating a comment, viewing a thread, voting a thread, voting a response, and searching forum. The first finding is the average of the participation rate in the discussion forum by time interval. The participation rate of a time interval was measured with the percentage of numbers of discussion actions in specified time interval compared with the total number of discussion actions in the forum for a specific course as shown in Figure 21. In general, ChMOO1x and ChMOO2x courses have a common trend in which the typical time intervals of the participation were 12.01 – 16.00 and 20.01 – 04.00. Although in ChMOO1x course, the highest participation rate was between 12.01 and 16.00, while in ChMOO2x course, the highest participation rate was between 20.01 and 24.00. Contrarily, the highest participation rate of ChMOO6x course was between 04.01 and 08.00, while another typical time interval of the participation was between 16.01 and 24.00. Secondly, Figure 22 showcases the distribution of forum participants by places. The distribution was divided into two categories, single place and multiple places that indicate the percentage of numbers of forum participants who conducted overall discussion actions in either one same location or at least two different locations compared with the number of forum participants. A general trend can be found in three courses, in which almost all forum participants performed discussion actions from one same location with the percentage of more than 80%. Thus, less than 20% of the forum participants carried on discussion actions from different places.

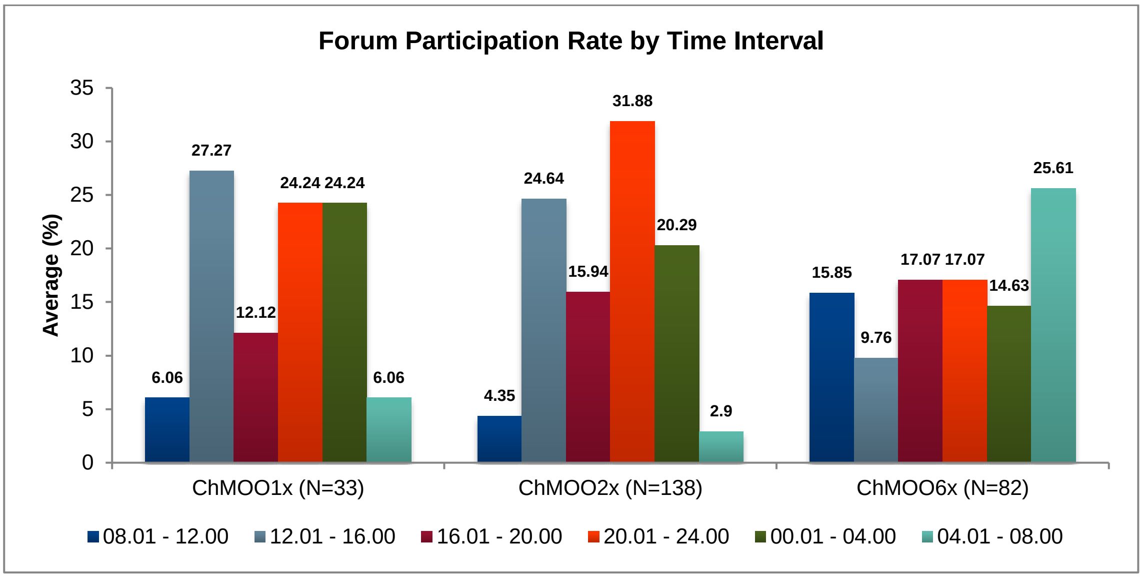

Figure 21. Average Forum Participation Rate by Time Interval for All Courses

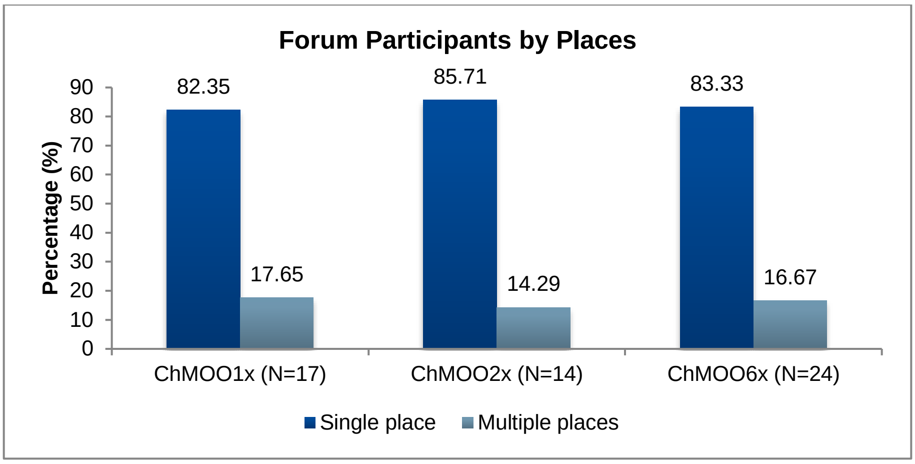

Figure 22. Forum Participants by Places for All Courses

5.2.5. Community – Rules – Object

Evidently, the finding of Community – Rules – Object dimension of activity system is relatively simple. As mentioned in Section 4.3.2, active and passive participation were calculated for each of the selected courses. Active participation consisted of creating a thread, creating a response, and creating a comment. Meanwhile, viewing thread, voting a thread, voting a response, and searching in the forum were considered as passive participation. The forum participation for active participation for instance, was measured by the percentage of numbers of active discussion actions done by forum participants compared with the total numbers of forum participation.

Additionally, the rules in the community were represented by different settings in discussion action. ChMOO1x course, for instance, included discussion in the weekly instruction and created dedicated discussion topic for each module. ChMOO2x course put discussion as one of the assignments in the course, while ChMOO6x course was the least demanding when it comes to discussion.

As a result, the three selected courses show a similar trend where passive participation took precedence over active participation in the discussion forum as depicted in Figure 23. Regarding the gap between active and passive participation, it is not that apparent for ChMOO1x and ChMOO2x courses. However, ChMOO6x course has a significant difference between active and passive participation where 80.49% of the forum participation were not active contribution to the community.

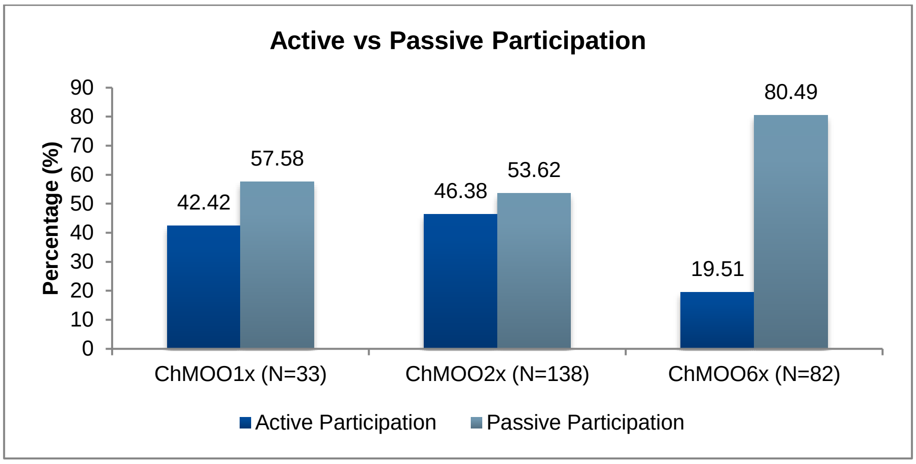

Figure 23. Overview of Active vs Passive Participation for All Courses

5.2.6. Community – Division of Labour – Object

Similar to the independent variables used in Subject – Division of Labour – Object dimension, the forum participants' age and educational background were used as independent variables with number of forum participations as a dependent variable. Pearson Correlation was computed to assess the correlation between the forum participants' age and number of forum participations. As showcased by Table 21, there was no correlation between the two variables for all selected courses: ChMOO1x course ($r = -.154$, $n = 13$, $p = .616$); ChMOO2x course ($r = -.230$, $n = 11$, $p = .497$); and ChMOO6x course ($r = .107$, $n = 17$, $p = .681$). Therefore, Hypothesis 5 that age has a negative effect on forum participation was not accepted and its null hypothesis that age does not have an effect on forum participation was retained.

Table 21. Correlations of Number of Forum Participation with Participants' Age

Course			**Age**
ChMOO1x	Number of Forum Participations	Pearson Correlation	-.154
		Sig. (2-tailed)	.616
		N	13
ChMOO2x	Number of Forum Participations	Pearson Correlation	-.230
		Sig. (2-tailed)	.497
		N	11
ChMOO6x	Number of Forum Participations	Pearson Correlation	.107
		Sig. (2-tailed)	.681
		N	17

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

On the other hand, the educational background samples of the three selected courses failed to pass assumptions to run Jonckheere-Terpstra test. The test was directed to assess statistically significant trend between forum participants' educational background and number of forum participations. The data from the three selected courses violated the assumption that the distributions in each group have same shape and same variability (See Appendix 9 for the assumption test). Hence, the alternative test that does not consider the ordinal nature of educational background variable, Kruskall-Wallis H was conducted. As presented in Table 22, the Kruskall-Wallis H test showed that there was no statistically significant difference in number of forum participation between the different educational background levels for the three courses: ChMOO1x course ($\chi^2(2) = 2.766$, $p = .251$); ChMOO2x course ($\chi^2(2) = 3.200$, $p = .202$); and ChMOO6x course ($\chi^2(2) = .833$, $p = .659$). Furthermore, the alternative hypothesis that there is a significant difference between different levels of educational background on forum participation was not accepted and its null hypothesis that there is no significant difference between different levels of educational background on forum participation was retained.

Table 22. Differences on Forum Participation between Mobile Learners' Educational Backgrounds

Course			**Educational Background**
ChMOO1x	Number of Forum Participation	Kruskall-Wallis H	2.766
		df	2
		Asymp. Sig.	.251
		N	14
ChMOO2x	Number of Forum Participation	Kruskall-Wallis H	3.200
		df	2
		Asymp. Sig.	.202
		N	11
ChMOO6x	Number of Forum Participation	Kruskall-Wallis H	.833
		df	2
		Asymp. Sig.	.659
		N	16

*. Difference is significant at the 0.05 level

6. Discussion and Conclusion

In this study, an examination of MOOC format that enables mobile learning practice was conducted. The study mainly looked into the format of the course, assessment characteristics, and community building in MOOC setting based on Sharples *et al.*'s criteria of mobile learning incorporated with activity system components derived from Engeström's expansive model of activity system.

To further examine mobile learning practice in MOOC, an attempt to investigate the pattern of learners' practices when using MOOC in mobile phones was made. The study applied Activity-Oriented Design Model by Mwanza (2009) as a framework to identify the analytical questions and develop a set of hypotheses concerning mobile learning practice in MOOC derived from the specified analytical questions based on activity system theory. Correspondingly, the following research questions were answered based on the findings described in the Results section:

1) How do the format of the course, assessment, and community building in MOOC setting enable mobile learning practice?
2) What is the pattern of learners' practices when using MOOC in mobile phones by focusing on video lecture interaction and discussion activity?
3) Does the characteristic of video lecture in mobile MOOC such as video length and follow-up quiz, influence learner engagement in terms of video completion rate?

Finally, mobile learning practice in MOOC were examined in the perspective of the activity system based on activity theory by Engeström (1987), both conceptually and practically. The conceptual model of MOOC and Mobile MOOC based on activity-based mobile learning theory by Sharples *et al.* is presented in Figure 24. Furthermore, the findings of the study per hypothesis are summarized in Table 23 and Table 24. Table 25 shows the operational process map model as a final step in Activity-Oriented Design Model Framework by Mwanza (2009). This model is used to represent the transition of sub-activities, activity components and its relations, analytical questions that guide the research, and also importantly the contradictions identified in focused activities.

6.1. RQ1: MOOC in Perspective of Mobile Learning

Generally speaking, MOOC setting and format enable mobile learning based on Sharples *et al.*'s criteria (2006). Sharples *et al.* defined that a learning setting can be considered as mobile learning if it is different from classroom or workplace learning, as well as enabling mobility, formal and informal learning, constructive and social process, along with personal and situated activity mediated by technology. Additionally, in the perspective of activity system model, Sharples *et al.* (2006) defined two layers of activity system components, a semiotic layer that includes cultural rules, community, and division of labour; as well as the technological layer to magnify the role of technology that contains control, context, and communication. Altogether, these activity system components are used as identifying objects for evaluating mobile learning criteria as outlined in Table 2.

One could argue that the MOOC format in this study was based on traditional classroom lectures. Since the learning objectives such as curriculum, timeline, and learning materials were pre-defined by the instructors (Yousef *et al.*, 2014; Anders, 2015; Kesim & Altinpulluk, 2015). This format is commonly referred as instructor-paced in MOOC. However, MOOC also offers self-paced courses with no due dates for assignments where learners can progress at their speed. This makes MOOC is distinct compared to classroom. Furthermore, according to Sharples *et al.* (2006), in classrooms, the focus of control is hardly carried out by the teacher, while in mobile learning the control may be distributed across learners, instructors, technologies, or other supporting resources such as books, buildings, animals, or plants. Additionally, learners have full control of using the technology to engage with the course in MOOC, for instance, choosing to access the course through computers, laptop, or mobile phone. Besides, MOOC also enables a distinct learning setting in which learners can access course materials when convenient and control the pace and style of interaction (Sharples *et al.*, 2006).

Sharples *et al.* (2006) argued that an obvious and essential characteristic of mobile learning is that learners are continually on the move. Conceptually, MOOC learners are able to learn across space where they engage with learning resources in one location then continue to develop or apply the knowledge in other locations. Apart from learning across space, MOOC not only supports learning across time but also reflecting the knowledge that was acquired before in different context. Since learners have full control and flexibility to engage with the course when convenient including their spare time. It is specially possible with the mobile app of MOOC that eliminates the hassle of having to open a laptop, connect to wireless or cable network, access, and login to the MOOC website. In summary, Sharples *et al.* (2006) suggested that moving in mobile learning goes beyond moving from classroom to classroom within school context, thus he concluded that

> "*mobility of learning means that knowledge and skills can be transferred across contexts such as home and school, how learning can be managed across life transitions, and how new technology can be designed to support a society in which people on the move increasingly try to cram learning into the interstices of daily life*" (p. 2).

To enable both formal and informal learning, Sharples *et al.* (2006) argued that one has to support successful and effective learning. According to The US National Research Council (1999), effective learning is learning that focus on learner, knowledge, assessment, and community. Having said that, although the course in MOOC is practically free, the given curriculum and materials are based on validated knowledge from trustworthy universities or organisations. The course is designed and delivered in a way learners can integrate the provided knowledge and their own experiences. MOOC not only provides lectures but also assesses and verifies learners' knowledge to give a sense of achievement and constructive feedback. Toven-Lindsay *et al.* (2015) mentioned that MOOC adopts the standard form of evaluation in traditional classrooms, such as multiple choice assessment and group topical discussion. The learners are not only engaged in peer review to enhance social activities but also to share knowledge and experience within the community. It is aligned with the European Commission who suggested that MOOC allows "*interactive possibilities (between peers or between students and instructors) that facilitate the creation of learning community*" (p. 2).

Since there is no constraint in choosing the place and context to access the learning materials in MOOC, learners have the opportunities to engage in situated learning that is embedded within a particular activity, context or culture (Lave & Wenger, 1990). As an example, a learner in Sustainability in Everyday Life course (ChMOO2x) can learn about food and water from the course while observing a real-life situation. Other than that, MOOC builds a community wherein the social interaction and collaboration as essential components of situated learning are developed. The last but not the least, learning in MOOC will not be possible without technology such as computers, laptop, or mobile phone. At last, MOOC and mobile learning can go hand in hand because of their similar nature, as quoted by de Waard *et al.* (2011a),

> "*when looking at mLearning and MOOC one cannot help but see similarities in its time and space autonomy, the community that is built, and the contextualization that takes place by the fact that everyone brings their experience to the center of learning community*". (p. 6)

6.2. RQ2: The Pattern of Learners' Practices in Mobile MOOC

Although two out of three courses showcased the highest number of learners who dropped out from video lectures, more learners were reported to complete video lectures progressively rather than in one go in all three courses. The lowest level of engagement concerning video lectures was found in ChMOO6x course that had the lowest number of average active rate, aligned with the incomplete rate being the highest compared to instant complete and progressive complete rates.

In addition, the result found that the learners who gradually completed video lectures in multiple time intervals were almost tied with learners who completed video lectures within the same time interval, even though the latter was leading in two courses. With respect to the mobility of spaces, a similar trend was showcased by the result for three courses. The percentage of learners who completed video lectures in one place and multiple different places were almost the same with the former being slightly higher in two courses. The same course that had highest progressing completion action rate in multiple time intervals also showed that more than half of the learners completed the video lectures gradually in multiple different places. As de Waard *et al.* (2011a) advised, MOOC on mobile devices allow for knowledge creation to happen over time without being tied to a particular space and context.

Temporal independence characteristic in which the learners can learn at a time and space that is comfortable for them was demonstrated by the finding of learners who completed video lectures in one go (de Waard *et al.*, 2011a). The video completion time was distributed at all intervals means that learners were not forced to access the learning materials in a particular time. Interestingly, more than 40% of the learners in ChMOO2x and ChMOO6x courses completed video lectures between 16.00 and 24.00. Arguably, this finding could support the theory that mobile learning allows learners to fit learning into their daily activities or spare time.

The finding, however, could not elaborate whether mobile devices allow learning from anywhere. The instant complete actions implied that the majority of learners were still dependent on wireless network (Wi-Fi) coverage to complete video lectures. Although there was no indication if these learners intentionally selected a location with the Wi-Fi or it just happened to be a place with Wi-Fi. But one can speculate that the availability of Wi-Fi is one of the prerequisites to find a convenient place to study despite the cellular data offered by mobile phones. The possible reasons would be that it is still relatively costly to consume video using cellular data or simply because of poor mobile network coverage thus learners prefer the Wi-Fi that is more stable. A similar argument was stated by de Waard *et al.* (2011a) that concerning the challenge in mobile learning. The technology and accessibility as the key elements to access the knowledge might move potential learners who live in the less developed area or come from weaker socio-economic background away from being fully engaged in this learning shift. With that said, in contrast with what Hummel *et al.* (2002), O'Malley *et al.* (2005), or MoLeNET suggested, the notion of mobility in mobile learning cannot be necessarily associated with anywhere and anytime concept. Instead, by embracing its constraints and challenges, mobile can be defined as 'just-in-time' or 'when needed', in fact also enable time and space autonomy.

Another common conceptualisation of mobile learning is that the learning happens when a learner is moving to a different place. Even though the finding in this study suggested that a significant number of learners completed video lectures gradually in multiple different locations, but it did not indicate that the learning occurred during the move or when travelling for instance. Vavoula's study of everyday adult learning in 2005 reported that only 1% of learning episodes taken place on transport. It suggested that one does not have to correlate mobile learning with physical movement. Besides, Kakihara and Sørensen (2002) argued that being mobile is more than just people travelling. It also corresponds with the interaction they have with other people, objects, symbols, and space itself.

Another finding to be discussed is the correlation between learners' age and educational background with video completion rate. At the beginning of the study, a hypothesis that age has a negative effect on video completion rate was established. As a result, the alternative hypothesis was not accepted and the null hypothesis was retained because no correlation found between the two variables. Similar to the age demographic of enrolled learners that were dominated by learners between 26 and 40 years old, video completion rate data was also heavily distributed for age between 20 and 40 years old. Likewise, the hypothesis that there is a significant difference between different levels of educational background on video completion rate was not accepted although a statistically significant trend of higher median video completion rate with higher levels of educational background was found for ChMOO1x course. Despite this finding, the overall result was still insufficient to accept the alternative hypothesis. However, no reasonable argument could be found to explain the finding based on the analysed characteristics. When being compared, the enrolled learners and video completion rate distributions by educational background did not demonstrate similar trends. Despite being the lowest percentage in enrolled learners' distributions, high school or less group showed a higher mean of video completion rate value than college or advanced degree, especially in ChMOO2x and ChMOO6x courses. One possible reason could be there were more learners in college and advanced degree thus the range of video completion rate value became larger.

When it comes to the learners' pattern in participating in the discussion forum, the study was looking into time and place dimension. Six different time intervals in which the participants engaged in the discussion forum were defined. A similar trend as the video interaction was found for forum participation, where it was distributed through all time intervals thus the temporal independence was also supported within the community. Besides, the fact that each of the courses had a different most popular time interval of forum participation may demonstrate how mobile devices allow convenient access to discussions anytime, although not necessarily anywhere (Motiwalla, 2007). As an example, more than 30% of forum participation in ChMOO2x course occurred between 20.00 and 24.00 when arguably outside school or working hours. One can suspect that learners were able to instantly engage with discussions among their daily activities or during their spare time by using mobile phones. Without focusing on the technological side, it is true that the owners carry their mobile phone consistently for up to 24 hours. Thus learners can jump into the course whenever they have interest and time (Sharples *et al.*, 2015). In a broader spectrum, Motiwalla (2007) added that the nature of real-time or instant interactivity of mobile devices leads to a better decision-making.

Generally, based on its contribution to the community, forum participation can be distinguished as active and passive participation. Passive participation does not indicate the absence of engagement, yet participants do not directly share questions, thoughts, or opinions. In the study, participants engaged passively by viewing thread, searching forum, voting thread or other participant's response. Meanwhile, posting thread, comment, and response were considered active participation. Overall, the study found that passive participation still took precedence over active participation despite the different rules of discussion in the three selected courses. However, having discussion as one of the assignments or merely incorporating discussion in weekly instruction and providing more organised discussion seemed to shorten the gap between active and passive participation. These strategies were used in ChMOO1x and ChMOO2x courses where the gap was no more than 15%. A different finding was showcased by the least demanding course concerning discussion activity, ChMOO6x, where the passive participation was four times higher than the active participation. Even though the study did not unfold its direct correlation, one could speculate that the strategies used by ChMOO1x and ChMOO2x courses may be an extrinsic motivation for learners to contribute actively to the community. With that said, passive participation is not necessarily irrelevant. Learners who lurk around in discussion forum actually consume the information given in the community, and that is part of a learning process.

Table 23. The Summary of Findings per Hypothesis

	Hypothesis	**Accepted?**	**Remarks**
H3	Age has a negative effect on video completion rate	Not accepted	No statistically significant correlation between age and video completion rate was found
H4	There is a significant difference between different levels of educational background on video completion rate	Not accepted	Statistically significant trend of higher median video completion rate with higher levels of educational background was found only for ChMOO1x course
H5	Age has a negative effect on forum participation	Not accepted	No statistically significant correlation between age and forum participation was found
H6	There is a significant difference between different levels of educational background on forum participation	Not accepted	No statistically significant difference between different levels of educational background on forum participation was found

A similar challenge was found when examining the correlation of learners' age and educational background with the number of forum participation. Having significantly smaller sample size compared to video interaction, Pearson Correlation was computed to validate established hypothesis that learners' age has a negative effect on forum participation. The hypothesis was not accepted because no correlation found between the two variables. Thus the null hypothesis that age does not have an effect on forum participation was retained. Meanwhile, the alternative hypothesis that there is a significant difference between different levels of educational background on forum participation was not accepted because no statistically significant difference in number of forum participation between the different levels of educational background was found. The similar pattern concerning learners' age and educational background effects on how they interact with video lectures and discussion forum may be an indication that there is neither dominant age group nor educational background in mobile MOOC regarding learning engagement. The finding of the effect of educational background on actual learning engagement is different from a survey-based study conducted by Shapiro, Lee, Roth, Li, Çetinkaya-Rundel, and Canelas in 2017, where the learners with bachelor degree had more positive attitude toward MOOC activities than those who had not completed college degree or those who had an advanced degree. The study suggested that the participants with lower level of formal education were more likely to feel lost or frustrated, while those who had an advanced degree were more likely to view the courses more critically through a perspective of academic reviewer. Overall, the summary of the findings per hypothesis is presented in Table 23.

6.3. RQ3: The Effect of Video Lecture Characteristics in Mobile MOOC on Engagement

As suggested by Guo *et al.*'s study (2014) that shorter MOOC videos are more engaging, this study proposed a hypothesis that video length has a negative effect on video completion rate. The result shows that there was a negative correlation between video length and video completion rate that was statistically significant in the three selected courses. Hence, the alternative hypothesis suggested earlier was accepted. In other words, the increases in video length were correlated with the decreases in video completion rate. Additionally, Guo *et al.* (2014) also found that the shortest videos (0-3 minutes) had the highest engagement and the percentage of learners who attempted to answer assessment problems became smaller for longer videos. This finding has been supported by video producers in edX who recommend the instructors to split up the video lectures into smaller parts with 6 minute duration at maximum (Guo *et al.*, 2014). Unsupported hypothesis yet interesting from the same study suggested that a shorter video might contain instructional content with higher quality, as it requires thorough planning so that the video will be able to explain a concept within a short duration. In summary, shorter videos are more engaging, not only because of the length, but also its contents are more planned and straightforward.

However, deviance was found for the correlation between follow-up quiz and video completion rate. The alternative hypothesis that follow-up quiz has an effect on video completion rate was not accepted, and its null hypothesis that follow-up quiz does not have an effect on video completion rate was retained. The hypothesis was formulated based on Kovacs's study (2016) that investigated in-video quizzes effect on learners' video viewing behaviours in MOOC. He suggested that video dropout rate is lower in lectures that have in-video quizzes compared to other lectures that lack in-video quizzes. However, it is important to figure that, in-video and follow-up quiz is not necessarily the same. Kovacs defined in-video quiz as an embedded quiz inside video lecture to test learners' understanding of the video. Meanwhile, the follow-up quiz defined in this study is a separate quiz that follows a video lecture in the same subsection. In order to answer the quiz, therefore, a learner needs to go to the next page within the same subsection. In addition, there was no direct indicator for the quiz in a video lecture. In the edX platform, quiz indicator was given in the subsection header above the video. Despite the similarity that both in-video and follow-up quizzes are automatically graded, another apparent difference is that in-video quizzes are short and shown to learners upon reaching a certain point in a video lecture (Kovacs, 2016), while follow-up quizzes are not always short and consist of multiple questions. In the three selected courses of the study, a video lecture was not always followed by a quiz. Instead, a follow-up quiz was given after 2 or 3 video lectures, and the quiz covered questions from the previous video lectures. Therefore, the characteristics of quizzes need to be taken into account when being investigated as an influence to video lecture engagement, for instance, the completion rate. In summary, the findings per hypothesis are specified in Table 24.

Table 24. The Summary of Findings per Hypothesis (Subject - Rules - Object)

	Hypothesis	**Accepted?**	**Remarks**
H1	Video length has a negative effect on video completion rate	Accepted	Statistically significant negative correlation between video length and video completion rate was found for all selected courses
H2	Follow-up quiz has an effect on video completion rate	Not accepted	Statistically significant correlation between variable follow-up quiz and completion rate was found only in ChMOO6x course

6.4. Mobile Learning Activity in MOOC

As previously stated, this study based the mobile learning analysis primarily on Sharples *et al.*'s theory of mobile learning that corresponded with the expansive model of activity system by Engeström. It was Engeström who introduced two interacting activity system of individual and collective activities, represented by six different elements, subject, tools, object, community, rules, and division of labour. The expansive model of activity system is depicted in Figure 5 (Engeström, 1999a). Correspondingly, Sharples *et al.* (2006) proposed two perspectives of tool-mediated activity to highlight the role of technology in a learning activity, named semiotic and technological layer. The semiotic layer consists of existing elements from Engeström's expansive activity system model, rules, community, and division of labour. Meanwhile, the technological layer includes aspects involving control, context, and communication that should pinpoint the technology role in an activity system.

Figure 24 shows the conceptual model of semiotic and technological layer components that satisfy Sharples *et al.*'s criteria that enable mobile learning in MOOC. The figure shows that MOOC format from both semiotic and technological layers generally satisfy mobile learning criteria from Sharples *et al.* including difference with classroom, workplace, or lifelong learning; formal and informal learning; constructive and social process; as well as personal and situated activity mediated by technology. Meanwhile, mobile MOOC as a smaller part of MOOC supports mobility feature as a distinctive characteristic of mobile learning. In this case, mobile MOOC is defined as MOOC that can be accessed at a time and space that is convenient for learners. From a technological perspective, MOOC accessed through desktop or PC does not support mobility due to its fixed location and cable-connected network requirement. Therefore, a technology that enables mobility is required to achieve mobile learning in MOOC. Apart from mobile phones or tablets, one could argue that laptop or notebook can be conveniently used by learners to access MOOC whenever and wherever they want. Additionally, Naismith *et al.* (2002) classified laptop or notebook into portable and personal class of mobile technologies (See Figure 4) despite its lack of spontaneity as one of the important characteristics of mobile learning by Traxler (2005).

Overall, mobile learners and discussion forum participants who interact with mobile MOOC application to acquire knowledge and participate in community constitute a "*distributed system in which people and technology interact to create and share meaning*" (Sharples *et al.*, 2006, p. 230). MOOC enables not only individual activities concerning video lectures but also collective level where multiple people from different age groups, educational backgrounds, and roles participate and engage in a discussion forum. Further, a collective activity system is hardly triggered by the common motive that is embedded in the object of activity. The learning material as the object of mobile MOOC practice is a generalised learning material that carries the cultural motive of improving skills or obtaining acknowledgement for carrier purpose, for instance. The object and motive give actions such as completing a video lecture, read a discussion thread, or ask questions in discussion forum their continuity, coherence and meaning (Engeström, 2000).

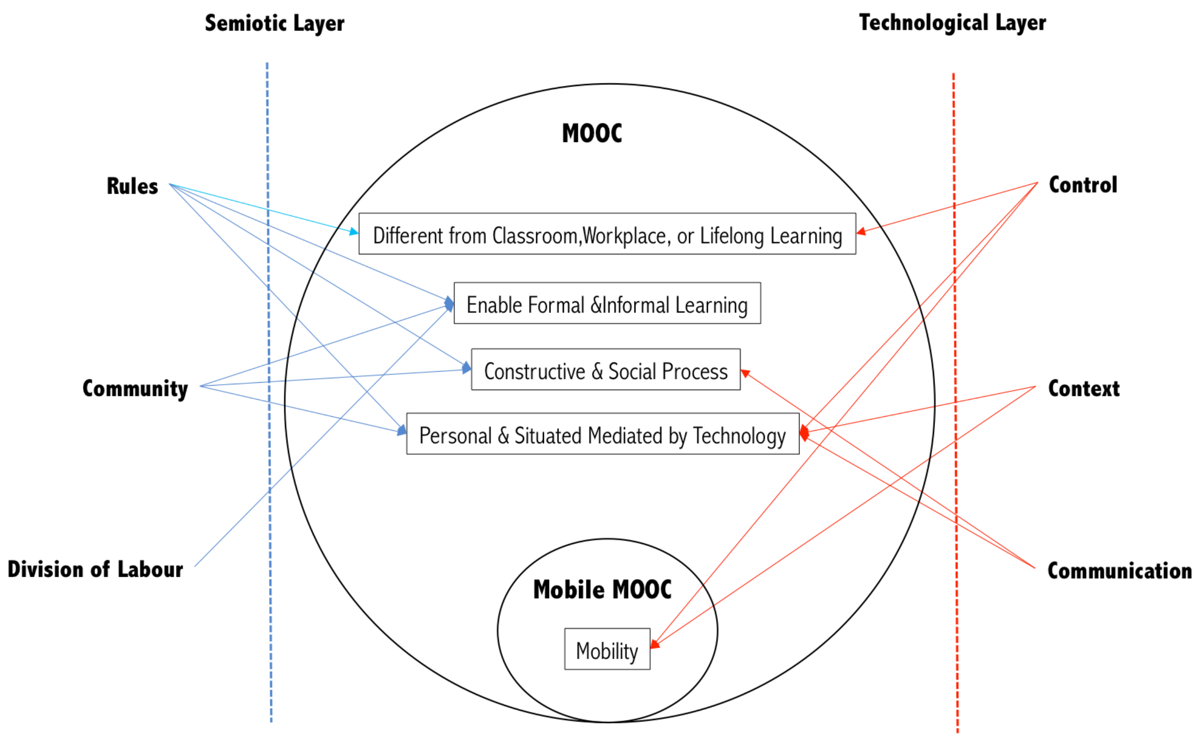

Figure 24. Conceptual Model of Semiotic and Technological Layer Components that Satisfy Sharples et al.'s Mobile Learning Theory Criteria in MOOC

According to Engeström (2000), the distinction between short-lived goal-directed actions and durable – object-oriented activity is the central importance in activity theory. Actions in MOOC context such as watching a video lecture have a temporally clear-cut beginning when a learner plays the video and end when the learner either complete or drop out of the video (Engeström, 1987). Meanwhile, Engeström defined activity as "*a collective, systemic formation that has a complex mediational structure. ..., activity is not reducible to actions.*" (1987, p. 234). Ultimately, Engeström suggested that activity systems realise and reproduce themselves by creating actions and operations. Goal-directed actions and operations are more or less independent, but the unit of analysis is understandable only when interpreted together with other elements in activity systems (Engeström, 2000). As an example, watching a video lecture action is analysed by incorporating the learners as the subject of activity, the mediating tool, and the video lecture itself as the object of activity.

Finally, Engeström (1999b) accentuates the importance of contradictions within activity systems to drive change and development. First of all, rather than referred as problems or conflicts, he described contradictions as structural tensions within and between activity systems that accumulated historically. In addition, he also specified different sources of tension in an activity system. First, tension within the element of an activity system, for instance, the technical constraint of mobile phones, e.g., smaller screen or limited keyboard area that might have an effect on how learners perform activities in MOOC. Next, the tension between elements of an activity system, for instance, the video length in MOOC (rules) may influence whether learners (subject) more likely to complete the video or not. He also added that when an activity system adopts new element (e.g., new tool or a new object) from the outside, it leads to a contradiction where some existing elements (e.g., rules or division of labour) discord with the newly adopted elements. In a concrete illustration, the mobile application of MOOC as the new tool in MOOC activity may cause the smaller screen size to be a new rule to be considered. As the final step of Activity-Oriented Design Model, operational process mapping model along with the identified contradictions is presented in Table 25.

Table 25. Operational Process Mapping Model of Mobile Learning Activity in MOOC

Sub-Activity Systems	Analytical Questions Generated	Identified Contradictions
 **Subject – Tool – Object**	What is the pattern of learners' practices when using mobile MOOC to interact with video lectures?	• Video incomplete rate was the highest in ChMOO6x course • Wi-Fi usage was significantly high • The percentage of learners who progressively completed video in 1 time interval and place is higher than multiple ones for 2 courses
 **Subject – Rule – Object**	Does the characteristics of video lecture such as video length and follow-up quiz correlate to the way learners interact with them?	• Increases in video length were correlated with decreases in video completion rate • Unlike in-video quizzes, follow-up quizzes are not part of video lecture thus an activity to be done after a video lecture (be it complete or incomplete)
 **Subject – Division of Labour – Object**	Do different age and educational backgrounds correlate to the way learners interact with video lecture?	• Learners who completed video lectures were heavily distributed in age 20 – 40 years old group
 **Community – Tool – Object**	What is the pattern of forum participants' practices when participating in discussions of learning content?	• Majority of learners conducted discussions throughout the course from one same place
 **Community – Rule – Object**	Do different settings of discussion in the course influence the way the forum participants participating in discussions of learning content?	• Passive participation took precedence over active participation
 **Community – Division of Labour – Object**	Do different age and educational backgrounds correlate to the way forum participants participating in discussions of learning content?	• Distribution of forum participation by educational background for all courses are different, assumed because of different target learners

In the context of activity theory, such contradictions motivate innovation to change the activity and drive a continuous development of a new way of interacting with technology and new learning patterns within individuals or communities (Engeström, 1999b; Sharples *et al.*, 2006). This is supported by the finding of the study that more learners were found to progressively complete video lectures as well as a reasonable amount of learners who interacted with video lectures in different time intervals and places, reflecting the mobility offered by mobile phones. Looking back to the conceptual model of MOOC in Figure 24, Sharples *et al.* (2006) suggested that the dialectical relationship between semiotic and technological perspectives in mobile learning framework represents process of appropriation that is taken place when people use technology to support learning. Thus, as they also argued,

> "*there is a continual co-evolution of technology and human learning, with individuals, groups and societies simultaneously developing new modes of interacting with technology (such as text messaging) in parallel with adopting new patterns of learning (such as just-in-time learning and mobile collaborative learning). Each new development in either learning or technology creates pressures that drive the next innovation.*" (p. 14).

The fact that some learners were able to engage with the course at times and places that were convenient for them exhibits the evolution in learning pattern, where might not be supported when MOOC was only available for desktop environment. On the other hand, it is possible that the identified contradictions found in current mobile learning activity drive innovation to overcome them and evolve to new shape of activity system. As an example, high dependency of Wi-Fi that limit learning from anywhere notion can be reduced by better infrastructure, improved network protocol, or even more light-weight media that does not require high bandwidth. All in all, the aforementioned principles constitute an activity system that "*evolve over lengthy period of socio-historical time, often taking the form of institutions and organizations*" (Engeström, 1987, p. 234).

6.5. Conclusion

In conclusion, this study has found that from the conceptual perspective, MOOC format enables mobile learning based on Sharples *et al.*'s criteria. The course syllabus, assessment format, and learning setting make them different from classrooms, workplace, or lifelong learning. MOOC also enables formal and informal learning, as well as accommodates learning as a constructive and social process. Other than that, learning in MOOC is personal and situated activity mediated by technology. Finally, mobile devices as a new tool to be used in MOOC allow mobility as the distinctive feature of mobile learning.

Furthermore, this study has examined mobile learning practice in MOOC on mobile devices, specifically mobile phones. Based on the quantitative measurement conducted in the study, the temporal and space independence when learners engage with the course, particularly watching video lecture and participate in a discussion, has been demonstrated to some extent. In other words, learners have the flexibility to choose times or places that are convenient for them to learn. However, the accessibility of Wi-Fi still seems to be one of the important criteria for learners to engage with the course using mobile phone despite the availability of mobile data. In addition, the finding of the study concerning video length in MOOC is consistent with Guo *et al.*'s research (2014). It suggests that shorter videos are more likely to be completed, while the follow-up quiz does not have an effect on video completion rate. In regards to the discussion activity, mobile device usage does not seem to motivate learners to actively contribute to the community. Interestingly, the finding suggests that method such as having discussions as an assignment, incorporating discussion in weekly instruction, or providing more organized discussion seems to shorten the gap between active and passive participation. In regards to the profile of the mobile learners, the study found that there was neither a dominant age group nor a level of educational background who engaged with the course in terms of completing video lectures and participating in the discussion forum.

Nevertheless, other than the supportive findings, this study has also highlighted some contradictions that challenge the concept of mobility in mobile learning practices in MOOC. Whether or not the notion of mobile learning as learning from anywhere and anytime is hard to infer based on the scope and data of this study. Further, it needs more investigations and continuous research against the continuous development of technology and the evolution of learning pattern.

6.6. Limitations

It is important to realise that this study was conducted as a part of Master's Thesis thus time and resource constraints were inevitable. Without intending to reduce the quality of research, the study was tied to a certain scope hence some imperfections, uncovered area and limitations were present. This section discusses the limitations of the study and their implications for the obtained results. Please note that data limitations are presented in Section 4.3.1 and will not be discussed further in this section.

One of the main limitations encountered during the study was the type of mobile devices being examined. Due to some data limitations mentioned in Section 4.3.1, narrowing down the acknowledged mobile devices only to mobile phones, specifically the mobile application version of MOOC was decided, although learners can use browsers to access MOOC on mobile phones or Tablet. On the face of it, the generalisation was made based on a specific tool and does not necessarily represent other devices that can be used in a mobile learning activity.

Another limitation regarded MOOC actions as the focus of analysis in the context of activity theory. Watching video lecture and participate in a discussion was just a small part of learning activity as a whole to represent learning acquisition and participation metaphor in MOOC. Other than that, there were more variables, both independent and dependent, that can be measured to enrich the findings concerning mobile learning activity in MOOC. Other variables such as gender, roles, occupation, or geographical position are worth to take into account in future research. Another limitation concerned the dependent variables measured for engagement. Learning engagement was rather complicated and hard to quantify. Whether to define learners who engaged in video lecture only when they complete the video was questionable. In reality, there is no quantitative method to measure whether learners are actually watching or just playing the video in the background. Arguably, video completion is one of the necessary and quantifiable variables although not necessarily sufficient for learning in MOOC. Nevertheless, conscious decisions were made concerning the operationalisation procedure used in this study by taking into account the availability of data and time constraint.

6.6.1. Threats to Validity

Apart from the limitations of the study, it is also important to address the potential threats to the scientific validity that might be introduced by quantitative measurement and applied methods of the study. The possible threats are discussed and specified according to the types of validity threats by Onwuegbuzie (2000). He suggested that there are at least two types, threats to internal and external validity. Most of the threats to internal validity are applied to experiment, or case study thus is irrelevant for this study.

1) Threats to External Validity

   One of the possible threats that occur at research design or data collection stage is population validity. Population validity is in which findings are generalisable from the individual samples of the conducted study to the larger population of individuals, as well as across subpopulation within the larger population. Onwuegbuzie (2000) added that using large and random samples (convenience sampling) as being done in this study tend to increase the population validity of the results. However, random sampling does not guarantee to represent the target population. In addition, the samples that involved age (date of birth) and educational background information might not represent the whole sampling size. This was caused by the voluntary nature of the information in the edX platform. A learner can choose not to provide an age or educational background information. Other than that, the risk of having incorrect value, for example, a learner who was not being honest about his date of birth, was also present.

Another possible threat in the study is temporal validity that refers to whether findings can be generalised across time. The findings of the study might not be relevant anymore when new technology is present, for instance, more lightweight video streaming technology for a better experience. Though these validities are the common threat in almost all studies, these factors should be kept in mind when drawing conclusions based on this study.

6.7. Further Research Recommendation

Even though this study did not focus on the technological perspective of MOOC, the finding provides an implication in the design of the courses. Particularly, the length of video lectures and quizzes related to video lectures. Through the outcome, this study supports the argument that shorter videos are more likely to be completed. Thus, splitting a long video lecture into smaller chunks is recommended to increase video engagement. Furthermore, exploring the possibility to have in-video quizzes on the platform will be interesting for video engagement.

In regards to the development, both MOOC and mobile learning have been popular research done individually. But there is a lot of rooms for exploration in the field of study that combining MOOC and mobile learning. Not to mention that MOOC has advanced to mobile devices and potentially other types of technology. Therefore, there are many relevant and exciting opportunities for further research. In this section, some of the research opportunities that are most relevant in the context of the study are presented.

First and foremost, other types of mobile devices have not been investigated in the context of the study due to the limited scope. As Sharples *et al.* (2006) pointed out that technology can shape how people interact and fit their behaviours in operating new tools, it is interesting to see if the consistent findings are achieved through other devices. Inspired by the limitations of the study, more insightful and comprehensive findings might be obtained when investigating more learning actions in the context of MOOC, as well as more variables related to video characteristics or engagement measurement.

Furthermore, this study was bounded to only answer “what” and “how” questions to some extent. It would be interesting to attempt to answer “how” and “why” questions in the context of mobile learning practice in MOOC. Hence, other research methods, mainly a qualitative inquiry can be conducted for further research. In summary, combining the specified area of research could not only contribute to scientific and academic purpose but can also be used in practice to improve online and massive learning methods in general.

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Appendices

Appendix 1. Snippet Code of Video Interaction Events JSON Processing Algorithm

```
public class VideoEventProcessor
{
  private const string EventType = "event_type";
  private const string EventSource = "event_source";
  private const string PauseVideo = "pause_video";
  private const string PlayVideo = "play_video";
  private const string LoadVideo = "load_video";
  private const string HideTranscript = "hide_transcript";
  private const string ShowTranscript = "show_transcript";
  private const string SeekVideo = "seek_video";
  private const string StopVideo = "stop_video";

  public VideoEventProcessor(SQLiteConnection dbConnection, JsonSerializer serializer,
    string content, Parameter parameter)
  {
    DbConnection = dbConnection;
    Serializer = serializer;
    EventParameter = parameter;
    Reader = new JsonTextReader(new StringReader(content))
    {
      SupportMultipleContent = true
    };
  }

  public SQLiteConnection DbConnection { get; set; }
  public JsonTextReader Reader { get; set; }
  public JsonSerializer Serializer { get; set; }
  public Parameter EventParameter { get; set; }
  public int EventCount { get; set; } = 0;

  public void Execute()
  {
    while (Reader.Read())
    {
      JObject jsonObject = Serializer.Deserialize<JObject>(Reader);

                    if (IsVideoEventType(jsonObject.GetStringValue(EventType)) &&
        jsonObject.GetStringValue(EventSource) == EventParameter.EventSource)
                    {
                      // get event id
                      var newId = Helper.GetNewId(DbConnection, EventParameter.TableName);

                      var clientOb = JObject.Parse(jsonObject["context"]["client"].ToString());

                      var ip = clientOb.GetStringValue("ip") ?? jsonObject.GetStringValue("ip");

        var eventOb = JObject.Parse(jsonObject["event"].ToString());

                      var code = eventOb.GetStringValue("code");

                      var id = eventOb.GetStringValue("id");

                      // inserting data
                      string sql = $"insert into {EventParameter.TableName} " +
          "(id, username, event_type, event_source, event_time, page,
          context_course_id, context_user_id" +
                        ", context_application_name, context_application_version,
          context_client_network_wifi" +
          ", context_client_network_cellular, context_client_locale,
          context_client_ip, context_client_device_model" +
          ", context_client_device_type, context_client_timezone,
          context_client_os_version" +
          ", context_client_os_name, context_client_screen_width,
          context_client_screen_height, event_code" +
          ", event_id";
```

```
          string sqlValue = " values " +
            " (" + newId +
            ", '" + jsonObject["username"].ToString() + "'" +
            ", '" + jsonObject["event_type"].ToString() + "'" +
            ", '" + jsonObject["event_source"].ToString() + "'" +
            ", '" + Convert.ToDateTime(jsonObject["time"]) + "'" +
            ", '" + jsonObject["page"].ToString() + "'" +
            ", '" + jsonObject["context"]["course_id"].ToString() + "'" +
            ", '" + jsonObject["context"]["user_id"].ToString() + "'" +
            ", '" + jsonObject["context"]["application"]["name"].ToString() + "'" +
            ", '" + jsonObject["context"]["application"]["version"].ToString() + "'"+
            ", " +
            Convert.ToInt32(jsonObject["context"]["client"]["network"]["wifi"]) +
            ", " +
            Convert.ToInt32(jsonObject["context"]["client"]["network"]["cellular"]) +
            ", '" + jsonObject["context"]["client"]["locale"].ToString() + "'" +
            ", '" + ip + "'" +
            ", '" + jsonObject["context"]["client"]["device"]["model"].ToString() +
            "'" +
            ", '" + jsonObject["context"]["client"]["device"]["type"].ToString() +
            "'" +
            ", '" + jsonObject["context"]["client"]["timezone"].ToString() + "'" +
            ", '" + jsonObject["context"]["client"]["os"]["version"].ToString() + "'"
            +", '" + jsonObject["context"]["client"]["os"]["name"].ToString() + "'" +
            ", " +
            Convert.ToInt32(jsonObject["context"]["client"]["screen"]["width"]) +
            ", " +
            Convert.ToInt32(jsonObject["context"]["client"]["screen"]["height"]) +
            ", '" + code + "'" +
            ", '" + id + "'";

          if (eventOb.ContainsKey("currentTime"))
          {
             sql += ", event_currentTime";
             sqlValue += ", " + Convert.ToDecimal(eventOb["currentTime"]);
          }

          if (eventOb.ContainsKey("old_time"))
          {
            sql += ", event_old_time";
            sqlValue += ", " + Convert.ToDecimal(eventOb["old_time"]);
          }

          if (eventOb.ContainsKey("new_time"))
          {
            sql += ", event_new_time";
            sqlValue += ", " + Convert.ToDecimal(eventOb["new_time"]);
          }

                              if (eventOb.ContainsKey("requested_skip_interval"))
          {
            sql += ", event_requested_skip_interval";
            sqlValue += ", " + Convert.ToDecimal(eventOb["requested_skip_interval"]);
          }
          sql += ")";
          sqlValue += ")";

          string aggregatedSql = sql + sqlValue;

          SQLiteCommand command = new SQLiteCommand(aggregatedSql, DbConnection);

          int result = command.ExecuteNonQuery();

          EventCount += result;

        }
      }
    }
  }
```

Appendix 2. Snippet Code of Discussion Events JSON Processing Algorithm

```
public class DiscussionEventProcessor
{
  private const string EventType = "event_type";
  private const string EventSource = "event_source";
  private const string CommentCreated = "edx.forum.comment.created";
  private const string ResponseCreated = "edx.forum.response.created";
  private const string ResponseVoted = "edx.forum.response.voted";
  private const string ForumSearched = "edx.forum.searched";
  private const string ThreadCreated = "edx.forum.thread.created";
  private const string ThreadVoted = "edx.forum.thread.voted";
  private const string ThreadViewed = "edx.forum.thread.viewed";

  public DiscussionEventProcessor(SQLiteConnection dbConnection, JsonSerializer
    serializer, string content, Parameter parameter)
  {
    DbConnection = dbConnection;
    Serializer = serializer;
    EventParameter = parameter;
    Reader = new JsonTextReader(new StringReader(content))
    {
      SupportMultipleContent = true
    };
  }

  public SQLiteConnection DbConnection { get; set; }
  public JsonTextReader Reader { get; set; }
  public JsonSerializer Serializer { get; set; }
  public Parameter EventParameter { get; set; }
  public int EventCount { get; set; } = 0;

  public void Execute()
  {
    while (Reader.Read())
    {
      JObject jsonObject = Serializer.Deserialize<JObject>(Reader);

      if (IsDiscussionEventType(jsonObject.GetStringValue("event_type")))
      {
        // get event id
        var newId = Helper.GetNewId(DbConnection, EventParameter.TableName);

        var eventOb = JObject.Parse(jsonObject["event"].ToString());

        // inserting data
        string sql = $"insert into {EventParameter.TableName} " +
          "(id, username, event_type, time, context_user_id, context_course_id, ip";

        string sqlValue = " values " +
          " (" + newId +
          ", '" + jsonObject["username"].ToString() + "'" +
          ", '" + jsonObject["event_type"].ToString() + "'" +
          ", '" + Convert.ToDateTime(jsonObject["time"]) + "'" +
          ", '" + jsonObject["context"]["user_id"].ToString() + "'" +
          ", '" + jsonObject["context"]["course_id"].ToString() + "'" +
          ", '" + jsonObject["ip"].ToString() + "'";

        if (eventOb.ContainsKey("body"))
        {
          sql += ", event_body";
          sqlValue += ", '" + eventOb.GetStringValue("body")?.Replace("'", "/")+"'";
        }


        if (eventOb.ContainsKey("truncated"))
        {
          sql += ", event_truncated";
          sqlValue += ", " + eventOb.GetIntValue("truncated") + "";
        }
```

```
if (eventOb.ContainsKey("category_name"))
{
  sql += ", event_category_name";
  sqlValue += ", '" + eventOb.GetStringValue("category_name")?.Replace("'",
    "/") + "'";
}

if (eventOb.ContainsKey("id"))
{
  sql += ", event_id";
  sqlValue += ", '" + eventOb.GetStringValue("id") + "'";
}

if (eventOb.ContainsKey("commentable_id"))
{
  sql += ", event_commentable_id";
  sqlValue += ", '" + eventOb.GetStringValue("commentable_id") + "'";
}

if (eventOb.ContainsKey("anonymous"))
{
  sql += ", event_anonymous";
  sqlValue += ", '" + eventOb.GetIntValue("anonymous") + "'";
}

if (eventOb.ContainsKey("anonymous_to_peers"))
{
  sql += ", event_anonymous_to_peers";
  sqlValue += ", '" + eventOb.GetIntValue("anonymous_to_peers") + "'";
}

if (eventOb.ContainsKey("title"))
{
  sql += ", event_title";
  sqlValue += ", '" + eventOb.GetStringValue("title")?.Replace("'", "/")+"'";
}

if (eventOb.ContainsKey("thread_type"))
{
  sql += ", event_thread_type";
  sqlValue += ", '" + eventOb.GetStringValue("thread_type") + "'";
}

if (!string.IsNullOrEmpty(eventOb.GetStringValue("user_forums_roles")))
{
  var userForumsRoles =
    JArray.Parse(eventOb.GetStringValue("user_forums_roles"));
                                        sql += ", event_user_forums_roles";
                                        sqlValue += ", '" + userForumsRoles.GetJoinStringValue() + "'";
}

if (!string.IsNullOrEmpty(eventOb.GetStringValue("user_course_roles")))
{
  var userCourseRoles =
    JArray.Parse(eventOb.GetStringValue("user_course_roles"));
  sql += ", event_user_course_roles";
  sqlValue += ", '" + userCourseRoles.GetJoinStringValue() + "'";
                  }

if (eventOb.ContainsKey("discussion"))
{
  sql += ", event_discussion_id";
  sqlValue += ", '" + jsonObject["event"]["discussion"]["id"].ToString()+"'";
}

if (eventOb.ContainsKey("response"))
{
  sql += ", event_response_id";
  sqlValue += ", '" + jsonObject["event"]["response"]["id"].ToString() + "'";
}
```

```
            sql += ")";
            sqlValue += ")";

            string aggregatedSql = sql + sqlValue;

            SQLiteCommand command = new SQLiteCommand(aggregatedSql, DbConnection);

            int result = command.ExecuteNonQuery();

            EventCount += result;
        }
    }
  }
}
```

Appendix 3. Snippet Code of Video Interaction Raw Data Transformation Algorithm

```
private const string PauseVideo = "pause_video";
private const string PlayVideo = "play_video";
private const string StopVideo = "stop_video";

private void Process()
{
  var usersQuery = $"select context_user_id, username from
    {InteractionParameter.UsersTableName}";

  SQLiteCommand usersCommand = new SQLiteCommand(usersQuery, DbConnection);

  SQLiteDataReader usersReader = usersCommand.ExecuteReader();

  while (usersReader.Read())
  {
    var username = usersReader["username"].ToString();
    var progressCount = 0;
    var instantComplete = false;
    var progressingComplete = false;
    var completeNetwork = 0;
    var completeTimeInterval = 0;
    var numberOfTimeIntervals = 0;
    var numberOfPlaces = 0;

    var viewAttemptsQuery = $"select count(*) from
      {InteractionParameter.SourceTableName} " +
      $"where event_id = '{InteractionParameter.VideoId}' and username = '{username}'"+
      $"and (event_type = '{PlayVideo}' or event_type = '{PauseVideo}' or event_type =
      '{StopVideo}')";

    SQLiteCommand viewAttemptsCommand = new SQLiteCommand(viewAttemptsQuery,
      DbConnection);

    var viewAttempts = Convert.ToInt32(viewAttemptsCommand.ExecuteScalar());

    if (viewAttempts > 0)
    {
      var interactionQuery = $"select id, context_user_id, username, event_id, " +
      $"cast(event_local_time as nvarchar(20)) as event_local_time, event_currentTime,
      " + $"context_client_network_cellular " +
      $"from {InteractionParameter.SourceTableName} " +
      $"where event_id = '{InteractionParameter.VideoId}' and username = '{username}'"+
      $"and (event_type = '{PlayVideo}' or event_type = '{PauseVideo}' or event_type =
      '{StopVideo}') " + "order by event_time asc";

      SQLiteCommand interactionCommand = new SQLiteCommand(interactionQuery,
        DbConnection);

                  SQLiteDataReader interactionReader = interactionCommand.ExecuteReader();

      while (interactionReader.Read())
      {
        var id = Convert.ToUInt32(interactionReader["id"]);
        var eventTime =
          Convert.ToDateTime(interactionReader["event_local_time"].ToString());
        var timeInterval = ConvertTimeInterval(eventTime);

        var eventQuery = $"update {InteractionParameter.SourceTableName} " +
          $"set event_timeinterval = {timeInterval} " +
          $"where id = {id}";

        SQLiteCommand eventCommand = new SQLiteCommand(eventQuery, DbConnection);
        eventCommand.ExecuteNonQuery();
        var videoTime = Convert.ToDouble(interactionReader["event_currentTime"]);
        var isVideoComplete = IsVideoComplete(videoTime);

        if (videoTime > 0)
        {
          progressCount++;
```

```
          if (progressCount == 1 && isVideoComplete)
          {
            instantComplete = true;
            completeNetwork =
              Convert.ToInt32(interactionReader["context_client_network_cellular"]);
            completeTimeInterval = timeInterval;
          }
          else if (progressCount > 1 && isVideoComplete)
          {
             progressingComplete = true;
          }
        }
      }

      if (progressingComplete)
      {
        var timeIntervalsQuery = $"select count(distinct event_timeinterval) " +
          $"from {InteractionParameter.SourceTableName} " +
          $"where event_id = '{InteractionParameter.VideoId}' and username =
          '{username}' " +
          $"and (event_type = '{PlayVideo}' or event_type = '{PauseVideo}' or
          event_type = '{StopVideo}') " +
          "order by event_time asc";

        var timeIntervalsCommand = new SQLiteCommand(timeIntervalsQuery,
          DbConnection);

        numberOfTimeIntervals = Convert.ToInt32(timeIntervalsCommand.ExecuteScalar());

        var placesQuery = $"select count(distinct context_client_ip) " +
          $"from {InteractionParameter.SourceTableName} " +
          $"where event_id = '{InteractionParameter.VideoId}' and username =
          '{username}' " +
          $"and (event_type = '{PlayVideo}' or event_type = '{PauseVideo}' or
          event_type = '{StopVideo}') " +
          "order by event_time asc";

        var placesCommand = new SQLiteCommand(placesQuery, DbConnection);

        numberOfPlaces = Convert.ToInt32(placesCommand.ExecuteScalar());
      }
    }
  }
}

private bool IsVideoComplete(double videoTime)
{
  if (InteractionParameter.VideoLength <= 30)
  {
    if (videoTime >= (0.95 * InteractionParameter.VideoLength))
    {
      return true;
    }
    else
    {
      return false;
    }
  }

  if (videoTime >= (InteractionParameter.VideoLength - 30) || videoTime >= (0.95 *
    InteractionParameter.VideoLength))
  {
    return true;
  }
  else
  {
    return false;
  }
}
```

Appendix 4. Example of Video Interaction: Active Rate Data per Video Lecture (ChMOO1x)

Video Id	#Mobile Learners	#Active Learners	Active Rate (%) *	#Learners with Incomplete Views	Incomplete Rate (%) **	#Learners with Instant Complete Views	Instant Complete Rate (%) ***	#Learners with Progressing Complete Views	Progressing Complete Views (%) ****
1	355	172	48,45	64	37,21	61	35,47	47	27,33
2	355	175	49,30	61	34,86	45	25,71	69	39,43
3	355	129	36,34	20	15,50	72	55,81	37	28,68
4	355	105	29,58	30	28,57	39	37,14	36	34,29
5	355	110	30,99	44	40,00	24	21,82	42	38,18

(*) Active Rate (%) = (Number of Active Learners / Number of Mobile Learners) * 100

(**) Incomplete Rate (%) = (Number of Learners with Incomplete Views / Number of Active Learners) * 100

(***) Instant Complete Rate (%) = (Number of Learners with Instant Complete Views / Number of Active Learners) * 100

(****) Progressing Complete Rate (%) = (Number of Learners with Progressing Complete Views / Number of Active Learners) * 100

Appendix 5. Example of Video Interaction: Instant Complete Rate Data per Video Lecture (ChMOO1x)

Video Id	#Learners with Instant Complete Views	#Instant Complete with Cellular Data	#Instant Complete 08.01 - 12.00	#Instant Complete 12.01 - 16.00	#Instant Complete 16.01 - 20.00	#Instant Complete 20.01 - 24.00	#Instant Complete 00.01 - 04.00	#Instant Complete 04.01 - 08.00
1	61	10	13	10	8	13	12	5
2	45	7	13	5	10	9	7	1
3	72	8	12	8	13	21	14	4
4	39	4	6	5	9	10	7	2
5	24	3	5	2	5	6	3	3

(*) Instant Complete Rate for Cellular Usage (%) = (Number of Instant Complete with Cellular / Number of Instant Complete Views) * 100

(**) Instant Complete Rate for Wi-Fi Usage (%) = (Number of Instant Complete Views) – (Number of Instant Complete with Cellular) / (Number of Instant Completes Views) * 100

(***) Instant Complete Rate for Time Interval A (%) = (Number of Instant Complete in Time Interval A / Number of Instant Complete Views) * 100

Appendix 6. Example of Video Interaction: Progressing Complete Rate Data per Video Lecture (ChMOO1x)

Vid Id	#Learners with Progress Complete Views	#Progress Complete 1 Time Interval	#Progress Complete 2 Time Intervals	#Progress Complete 3 Time Intervals	#Progress Complete 4 Time Intervals	#Progress Complete More than 4 Time Intervals	#Progress Complete 1 Place	#Progress Complete 2 Places	#Progress Complete 3 Places	#Progress Complete 4 Places	#Progress Complete More than 4 Places
1	47	30	15	2	0	0	27	18	1	1	0
2	69	47	15	6	1	0	52	9	5	3	0
3	37	29	6	2	0	0	26	9	1	1	0
4	36	25	9	2	0	0	26	8	1	1	0
5	42	24	12	4	0	2	23	12	4	0	3

(*) Progressing Complete Rate n Time Intervals (%) = (Number of Progressing Complete Views done in n different time intervals / Number of Progressing Complete Views) * 100

(**) Progressing Complete Rate n Places (%) = (Number of Progressing Complete Views done in n different places / Number of Progressing Complete Views) * 100

Appendix 7. Example of Video Constraints: Video Length & Follow-up Quiz and Completion Rate (ChMOO1x)

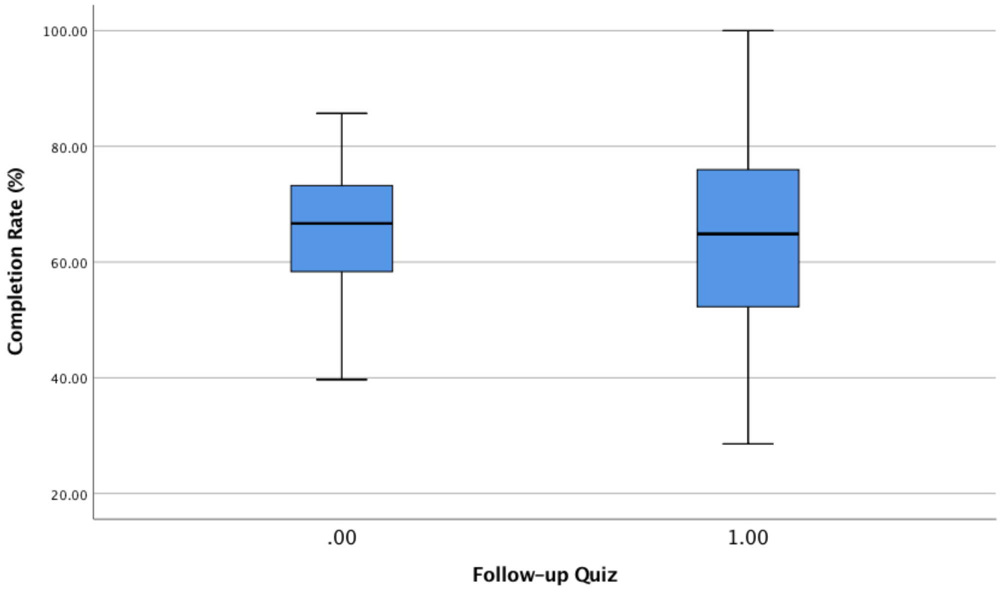
Video Length (s)	Follow-up Quiz	# Incomplete Views	# Complete Views	Completion Rate (%)*
209,33	0	64	108	62,79
375,4	0	61	114	65,14
72,21	1	20	109	84,50
202,62	0	30	75	71,43
476,33	0	44	66	60,00

(*) Completion Rate (%) = (Number of Complete Views) / (Number of Incomplete Views + Number of Complete Views) / 100

Appendix 8. Point-Biserial Correlation Assumptions Test on Follow-up Quiz and Video Completion Rate

1) ChMOO1x

Assumption #1: There should be no outliers for the continuous variable (completion rate) for each category of the dichotomous variable (Follow-up quiz).



Assumption #2: The continuous variable should be approximately normally distributed for each category of the dichotomous variable.

Test of Normality

		Shapiro-Wilk		
	Follow-up Quiz	Statistic	df	Sig.
Completion Rate	No	.982	37	.804*
	Yes	.992	27	.998*

*. Data is normal, because Sig. value is greater than 0.05

Assumption #3: The continuous variable should have equal variances for each category of the dichotomous variable. (**violated**)

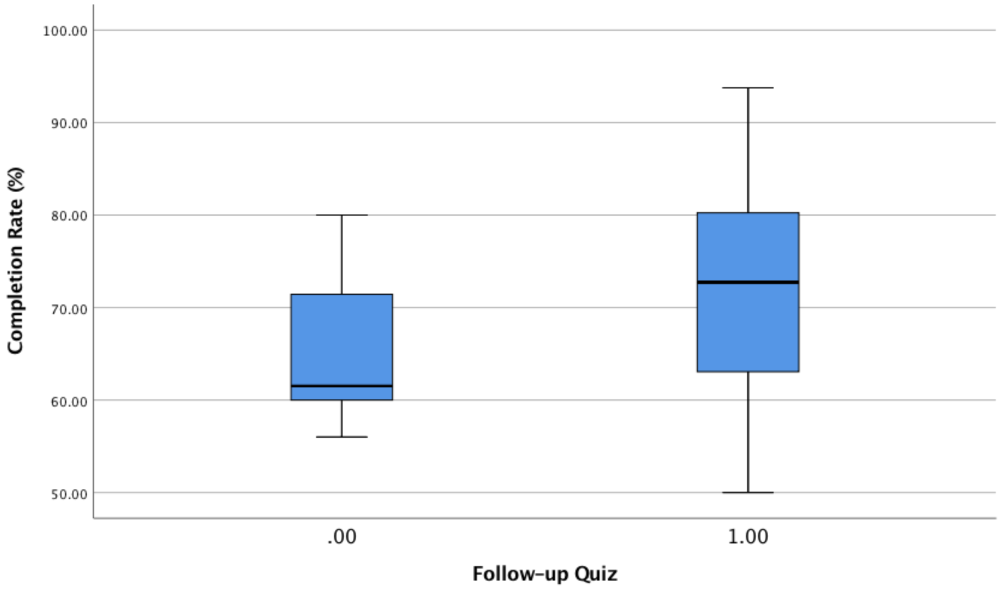
Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Completion Rate	Based on Mean	5.511	1	62	.022
	Based on Median	5.405	1	62	.023
	Based on Median and with adjusted df	5.405	1	50.146	.024
	Based on trimmed mean	5.498	1	62	.022

*. Group variances are equal if Sig. value is greater than 0.05

2) ChMOO2x

Assumption #1: There should be no outliers for the continuous variable (completion rate) for each category of the dichotomous variable (Follow-up quiz).



Assumption #2: The continuous variable should be approximately normally distributed for each category of the dichotomous variable.

Test of Normality				
		Shapiro-Wilk		
	Follow-up Quiz	Statistic	df	Sig.
Completion Rate	No	.850	10	.057*
	Yes	.970	39	.378*

*. Data is normal, because Sig. value is greater than 0.05

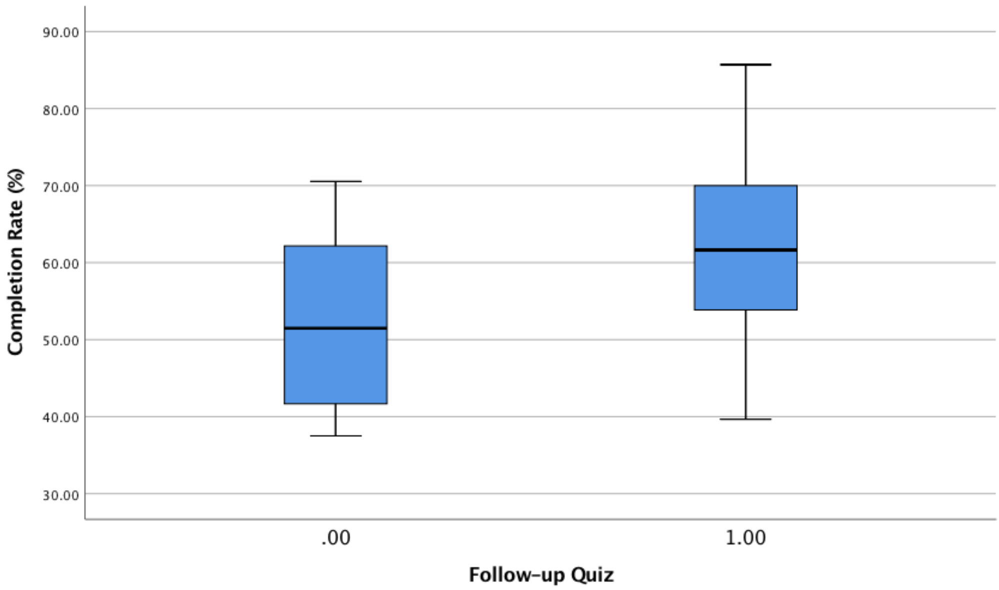
Assumption #3: The continuous variable should have equal variances for each category of the dichotomous variable.

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Completion Rate	Based on Mean	1.494	1	47	.228*
	Based on Median	2.244	1	47	.141
	Based on Median and with adjusted df	2.244	1	46.982	.141
	Based on trimmed mean	1.614	1	47	.210

*. Group variances are equal if Sig. value is greater than 0.05

3) ChMOO6x

Assumption #1: There should be no outliers for the continuous variable (completion rate) for each category of the dichotomous variable (Follow-up quiz).



Assumption #2: The continuous variable should be approximately normally distributed for each category of the dichotomous variable.

Test of Normality				
		Shapiro-Wilk		
	Follow-up Quiz	Statistic	df	Sig.
Completion Rate	No	.941	10	.569*
	Yes	.964	36	.287*

*. Data is normal, because Sig. value is greater than 0.05

Assumption #3: The continuous variable should have equal variances for each category of the dichotomous variable.

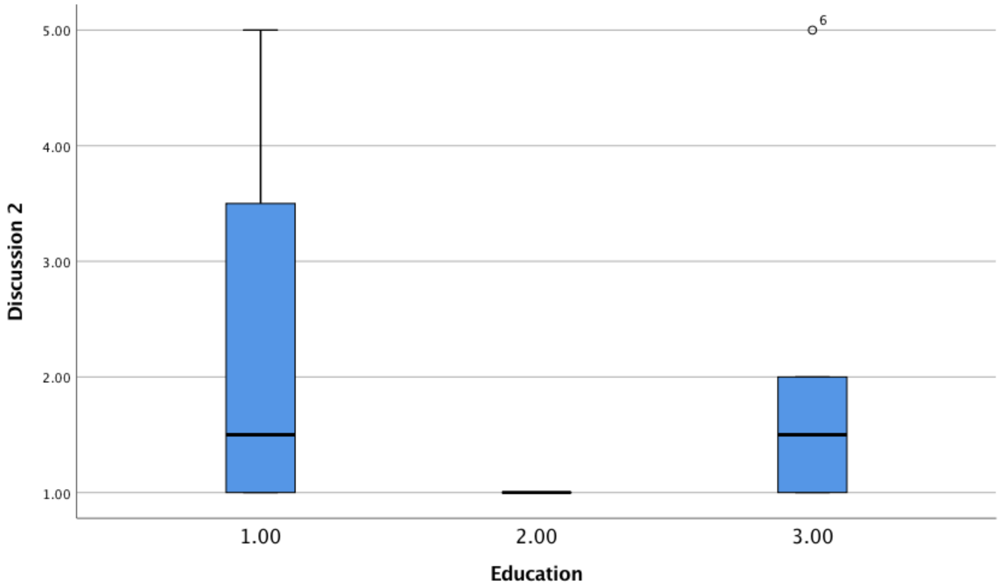
Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Completion Rate	Based on Mean	.028	1	44	.869*
	Based on Median	.035	1	44	.852
	Based on Median and with adjusted df	.035	1	43.691	.852
	Based on trimmed mean	.030	1	44	.863

*. Group variances are equal if Sig. value is greater than 0.05

Appendix 9. Jonckheere-Terpstra Assumption Tests on Forum Participants' Educational Background and Number of Forum Participations

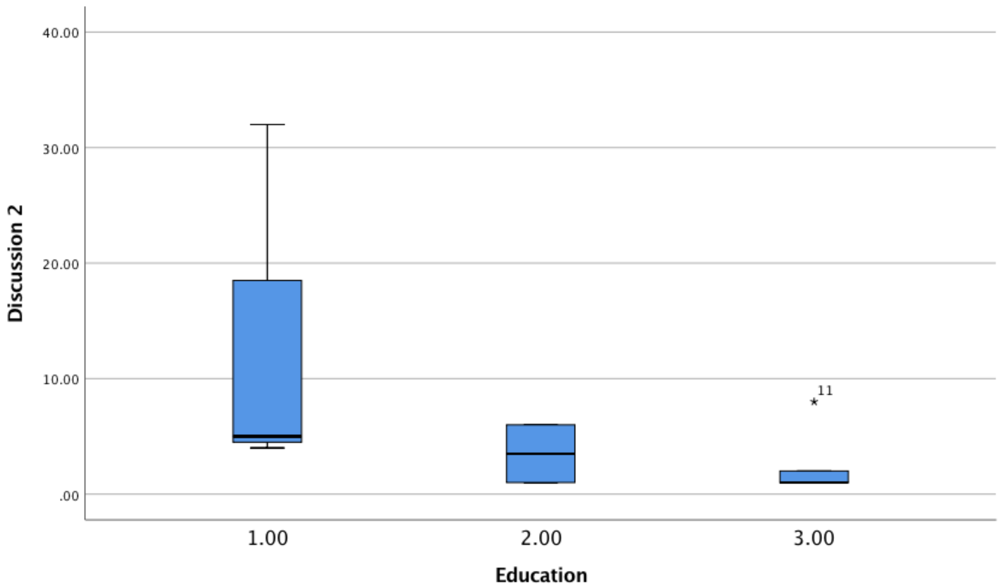
1) ChMOO1x

Assumption #1: The distributions of in each group of the independent variable have the same shape and the same variability. (**violated**)



2) ChMOO2x

Assumption #1: The distributions of in each group of the independent variable have the same shape and the same variability. (**violated**)



3) ChMOO3x

Assumption #1: The distributions of in each group of the independent variable have the same shape and the same variability. (**violated**)