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Determinants of sustainable frugal innovation in higher education: a massive open online courses perspective.

Determinants of sustainable frugal innovation in higher education: a massive open online courses perspective.

Dr. Shikha N. Khera[1], Himanshu Pawar[2]

[1] Designation: Assistant Professor, Affiliation Address: Delhi Technological University, Delhi School of Management, Bawana Road, Shahbad Daulatpur Village, Rohini, New Delhi: 110042, India. Email Id: shikhankhera@yahoo.co.in Alternate Email: shikhankhera18@gmail.com Mobile No.: +91 9810930801

[2] Designation: PhD. Scholar, Affiliation Address: Delhi Technological University, Delhi School of Management Email Id: himanshuihm1@gmail.com. Mobile No.: +91 7838969754 (author for correspondence)

ABSTRACT

Massive Open Online Courses (MOOCs) have evolved from open educational resources during the last decade at the right pinnacle of technological advancements and thus, online learning exponentially evolved and spread with the expansion of MOOCs across various streams. We aim to explore the conceptual foundations of sustainable frugal innovation in higher education using MOOCs as a form of frugal product that might help bridge the gap between underprivileged sections of the society and their higher education systems from a developing country perspective. Using a systematic review approach we have analysed definitions pertaining to both the concepts published in peer-reviewed journal articles (n=71) and cross-validated our findings from grass-root frugal innovators and higher education academicians via group interviews. Accessibility, affordability and resource scarcity were found to be the most crucial determinants of sustainable frugal innovation that MOOCs have successfully embraced over the years. Strengthening our case from a developing country perspective our results signify the importance of instituting a frugal approach towards proliferating MOOCs in such systems that either lack quality education or are devoid of resources and leadership necessary to bank upon the underlying power of e-learning.

Keywords: massive open online courses, MOOCs, frugal innovation, higher education, technology, e-learning

RESUMEN

Los cursos masivos abiertos en línea (MOOC) han evolucionado a partir de recursos educativos abiertos durante la última década en el pináculo de los avances tecnológicos y, por lo tanto, el aprendizaje en línea evolucionó y se extendió exponencialmente con la expansión de los MOOC en diversas corrientes. Nuestro objetivo es explorar los fundamentos conceptuales de la innovación frugal sostenible en la educación superior utilizando los MOOC como una forma de producto frugal que podría ayudar a cerrar la brecha entre los sectores desfavorecidos de la sociedad y sus sistemas de educación superior desde la perspectiva de un país en desarrollo. Utilizando un enfoque de revisión sistemática, analizamos definiciones relacionadas con los

conceptos publicados en artículos de revistas revisadas por pares (n = 71) y validamos de forma cruzada nuestros hallazgos de innovadores frugales de base y académicos de educación superior a través de entrevistas grupales. Se descubrió que la accesibilidad, la asequibilidad y la escasez de recursos son los determinantes más cruciales de la innovación frugal sostenible que los MOOC han adoptado con éxito a lo largo de los años. Reforzando nuestro caso desde la perspectiva de un país en desarrollo, nuestros resultados significan la importancia de instituir un enfoque frugal hacia la proliferación de MOOC en sistemas que carecen de educación de calidad o carecen de los recursos y el liderazgo necesarios para aprovechar el poder subyacente del aprendizaje electrónico.

Palabras clave: cursos masivos abiertos en línea, MOOC, innovación frugal, educación superior, tecnología, e-learning

INTRODUCTION

Innovation in education per se is a holistic concept which can be viewed from multiple perspectives for explaining the radical reforms over the years. What has evolved is not only a shift towards an engaged pedagogy i.e. one which has extensive institutional implications and not confined to changes in classroom dynamics (Saltmarsh et al. 2011), but also the inseparable role of technology in aiding such changes (Garcia et al. 2015). Al-Huneidi and Schreurs (2012) highlighted the prominence of flexible learning environments and collaborative online systems in refurbishing traditional educational ecosystem. These environments would not have existed if it were not for technological innovations to reach their existing forms; tabletPCs, classroom clickers, instant messaging and WebCT etc. (Blasco-Arcas et al. 2013). From the first use of computers in classrooms and universities towards the era of the internet, cloud computing and industry 4.0 technological innovation in education have seen expeditious growth. It wouldn't be wrong to presume that the nature of technological innovation inherits the essence of Kranzberg's second law of technology i.e. 'invention is the mother of necessity' (Kranzberg 1986). There exists a saturation point of every type or form of technology and its use; once reached it acts as a solid foundation for new technology to prosper and grow (Lawton, 2013). The evolution of open educational resources (OERs) to massive open online courses (MOOCs) can be considered as an apt example of how innovation in technology is changing the fabric of higher education. As soon as the availability and accessibility of internet became easy and cheap the OERs automatically evolved, which until the last decade were primarily meant for pre-recorded distance education purposes (Alario-Hoyos et al. 2017). OERs took ample time to advance from their static form to a much more dynamic MOOCs form but, with the pace at which machine learning and artificial intelligence are progressing we might soon be leapfrogging into future classroom transactions with augmented and virtual reality experiences (Leahy et al. 2019). But, before that materializes we must clear the air around the ongoing technological revolution in higher education and understand how we can leverage the underlying power of MOOCs as a type of frugal innovation for such higher education systems which are deprived of quality education. For instance: an innovation might be product innovation, process innovation or disruptive innovation etc. but, only the presence of certain attributes and distinctive features about their nature will help individuals to distinguish between them. We

believe the judicious apprehension of these features is one of the most effective ways to bank upon the underlying power of any type of innovation, which is also the underpinning theme of this article.

Over the last decade, researchers have focused on a new form of innovation (frugal) which we believe might be in sync with certain characteristics of MOOCs. Thus at first, we seek to examine the characteristic features of frugal innovation; which acts as an extended and improvised arm of innovation and has gained exponential momentum in the research domain over the last decade (Pisoni et al. 2018). Traces of this concept in actual practice dates back to ages in ancient civilizations and their philosophies (Tiwari et al. 2017) such as, the 'Greek Epicurean' ethics on fundamentals of living life with frugality and the movement of 'Neo Confucianism' in ancient China which appreciated simplicity and detachment to material self by one of its key proponents Lao-Tzu (Tiwari et al. 2017). However, academic research has just recently started to focus on the intricacies involved in defining frugal innovation and common grounds are being set up to hedge the unpredictable nature of the concept. According to Sharma and Iyer (2012), frugal innovation is a concept that "stems from resource scarcity: utilizing limited resources to meet the needs of low-income customers". Literature is replete with similar definitions which have faced barriers of subjective interpretations of the concept for example in India, the term 'Jugaad innovation' or in China as "Zizhu chuangxin (copycat)" or "jua kali" in Kenya (Radjou 2014) is constantly used in reference to frugal innovation but, the understanding, implementation and execution of the concept might wary across different countries and cultures (Tiwari et al. 2017). Nevertheless, it has been sincerely approached by authors such as Ray and Kanta Ray (2011), Zeschky, Widenmayer and Gassmann (2014) and Prabhu and Jain (2015) etc. in trying to define the boundaries and essential characteristics of such innovation thereby, providing our research with a concrete reference point for studying and understanding the determinants of frugal innovation in higher education sector from a MOOCs perspective.

Secondly, MOOCs on the sidelines of innovation in education technology have emerged as one of the most successful, widespread and sustaibale models for the dissipation of knowledge and learning through the use of e-learning platforms (Jordan 2015). It is observed that during the initial years of exploratory research on MOOCs, majority of the researchers divulged more into apprehending the impact, paradox, learning, feasibility, performance evaluation and effectiveness etc. of the concept. Major emphases on learning theories and new conceptual foundations (Gasevic et al. 2014) have rigorously been researched leading to the culmination of key traits and characteristic of MOOCs. Since its inception the concept has been a part of academic dialogue amongst scholars who view it as a form of 'disruptive innovation' (Flynn, 2013, Yuan & Powell 2013). Presumably, the authors believe that MOOCs wield the power for disturbing the make-up of our current educational system by changing the roles of student-teacher interaction and technology (Flynn 2013), which is true if we understand how one complements the other in presence of rapid technological advancements. On the other hand, scepticism looms over the same as few authors believe that the evolution of MOOCs from OERs is nothing more than a technological shift and it doesn't suffice the characteristics of disruptive innovation as mentioned in the literature (Al-Imarah & Shields 2018, Kursun 2016). Perelman (2014) viewed MOOCs as a symptom of disruption, not a major cause since according to him the academic bureaucracy believes that broadcasting online lectures can only put on a masquerade threat to the existing

institutional norms and state of affairs in education; nothing substantial. Thus, due to these differences in opinions it is still an ongoing debate and we leave it to the scholarly minds out in the field to figure out if MOOCs are actually disruptive in nature or not. We however, would like to examine if MOOCs adhere to the principles of frugality (thriftiness/skimping) since, frugal innovation in the education sector is not even remotely studied. We wish to accumulate key characteristics of MOOCs and frugal innovation under one common umbrella and propose to superimpose similarities of both the concepts to form a common ground for mutual co-existence.

Furthermore, we will be drawing and driving our discussions and conclusions from a developing countries' perspective for examining the potential for frugal innovation in MOOCs and vetting them with expert comments over our analysis of key definitions.

MATERIAL AND METHODS

In order to identify research papers with key definitions on both frugal innovation and MOOCs we have applied a systematic literature review (SLR) approach for determining an inclusion and exclusion criteria for article selection. SLR uses a through methodology to narrow down the scope of research for optimum use, re-use and feasibility (Liyanagunawardena et al. 2013). Textual analysis of the selected definitions for both the concepts was ideally performed by the authors and cross validated by experts in the fields of frugal innovation (primary education) and higher education research to minimize any form of bias arising due to subjective interpretations. We refrained from using automated text mining tools such as R-Studio, Python etc. since we are not working on the identification of key themes or word associations. We wish to make an educated guess at some highly likely explanations of the said text (McKee 2003) for which the feasibility of human interpretation is indispensable. We adhered to the same inclusion and exclusion criteria for searching research articles on frugal innovation and MOOCs.

Inclusion criteria: In order to funnel down and select high quality journals, we used the online database SCOPUS® for selection of research articles. Setting the publication language criteria to 'English' and using the keywords "MOOC" OR "Massive Open Online Courses" in 'title' OR 'abstract' OR 'keywords' and selecting only 'research articles' which are 'final published' we extracted a list of top (n=50) cited research papers on massive open online courses. Similar procedure was followed for research articles in frugal innovation (n=50) using the keywords "Frugal innovation" in 'title' OR 'abstract' OR 'keywords'. Therefore a consolidated list of (n=100) articles was prepared for analysis.

However, the initial number for our sample might seem to be arbitrary since, going for a fixed number does not guarantee the results one might require for qualitative analysis (Gergen et al. 2015). Therefore, we took this opportunity to also verify the concept of 'data saturation' (Fusch & Ness 2015) in qualitative analysis for our own research. In a major study conducted by Vasileiou et al. (2018) identified the key reasons behind sample size determination for qualitative research in health sciences and found that 55% of the studies reported determination of 'saturation level' of information as the benchmark for sample size justification. It was only appropriate to look for similarities in definitions up-to a certain point of information redundancy after which no new data could prove to be useful.

Exclusion criteria: Our study has focused only on published peer-reviewed research articles since we aim for high inclusion of quality not quantity. We are currently working only on the definitions of both the concepts thus; other published materials such as case studies, reports, conference proceedings, book review etc. did not fall in the scope for this research. We also withheld ourselves from selecting articles in press.

After reviewing the articles it was found that not all of them focused upon explicit definitions or characteristics of MOOCs thus, we removed those research articles from our list. Data from the sample further started to saturate at the final list of 30 articles for MOOCs and 41 articles for frugal innovation (see Appendix A for sample definitions and references) (n=71).

Elucidating definitions of MOOCs and Frugal Innovation: The definitions (see Appendix A) instantly gave away a quick and general understanding of researchers understanding of both the concepts. As, they expounded about MOOCs, it was found that the majority of them had a notion of MOOC as a free course whilst being open in nature. They are accessible from any part of the world to anyone who wishes to enrol and learn. The definitions consistently feature two major technological pre-requisites i.e. the presence of a digital device such as a laptop, computer or a mobile phone which can support MOOCs platforms and a good enough internet connection. Massive influxes of students attracted by top tier universities have laid the foundations for these courses thus, for an online course to be called a MOOC huge number of student enrolment is an important factor. Some of the authors believe, that in the right philanthropic mindset MOOCs have been efficient in removing the financial barriers for students coming from both developing and under-developed countries; allowing them to access high quality learning resources which otherwise would have been limited for them. Hence, they are also considered as a gateway for unlimited learning opportunities for students across all spectrums of socio-economic structures.

But, for MOOCs to be scrutinized as a form of frugal innovation they must hold true to the primary determinants of sustainable frugality such as affordability, accessibility and resource scarcity which, are the three most crucial aspects of frugal innovation as highlighted in the definitions. Since, the name speaks for itself resource constrained environments are at the core of defining frugal innovation thus, minimal use of resources is not a choice but a matter of human ingenuity and adaptability in problem solving using given resources at hand. Use of technology in such a way that minimizes not only the manufacturing cost but also the accessibility costs for destitute sections of the society is of major significance for every innovation to be considered frugal. It is interesting to note that majority of the frugal innovations are product centric i.e. the authors have till date focused only on those innovations which possess physical characteristics and their services as frugal innovation, for example Wonderbag (South Africa), ChotuKool (India), Aakash Tablet (India), BYD Lithium-ion batteries (China) etc. (Nevejan, 2016). Other definitions highlight the importance of a frugal mindset which in layman terms could be interpreted as, ‘an ability to work out of line with creativity at its behest’.

Understanding sustainable frugality in the context of its determinants (resource scarcity, affordability and accessibility) from a developing country (Indian) perspective: In a research conducted by Shah and Santandreu Calonge (2017) an attempt has been made to address the frugal power of MOOCs and how they could be utilized to access millions of displaced refugees in war torn countries of the middle east. They

developed a 'frugal MOOCs' model for school going Syrian refugees which addresses real issues of learners' needs, local stakeholders and technological challenges. It is quite evident from their model that without an established infrastructure (mobile and internet) and the help of local stakeholders in customizing learners' education needs the frugal MOOCs model will not suffice the end goal of making quality education accessible to underprivileged sections of the society. This is the power of frugality in innovation when resource scarce educational environments could access free and high quality learning materials from some of the top universities in the world. It is also worthwhile to note that majority of the frugal innovations have come from developing or under-developed nations since they share similar technological, economic and leadership challenges. Therefore, we now look at frugal innovation from an Indian perspective because the country has always been at the forefront of frugal or 'jugaad innovation' in the world (Radjou 2014) and dive deeper into the conceptual confluence of MOOCs as a form of frugal innovation.

Resource scarcity in frugal innovation is generally debated in the context of people living under the bottom of pyramid (BoP) (Pansera et al. 2016) thus, acting as the driving force for some form of frugal innovation to happen but, when we discuss about resource scarcity in the context of higher education and particularly MOOCs, it could not be denied that there is a huge chunk of students in developing countries who still do not have ways to leapfrog technological barriers (Davison et al. 2000). Further, educational institutions and teachers in these countries might not have an idea about the power of MOOCs in enhancing their academic acumen. Lack of awareness and alignment of learners' digital literacy, background and culture with content and medium of instruction is a major hindrance for effective dissemination of MOOCs in these areas. Thus, at first the environment needs to be conducive enough to support MOOCs as a form of frugal innovation in higher education. For example in India, the government is on a mission to expand the reach of internet services to the marginalized sections of the society which will not only help in financial inclusion for government schemes but could also be used to connect with educational institutions on both national and international levels. The same platform could be used by higher education institutions (HEIs) lacking quality education to aid their curriculum with learning materials and instructional teaching available at both government and private funded MOOCs platforms such as SWAYAM®, IITBx®, mooKIT® etc. But, the integration will only work if the educational institutions have the right intent to embed MOOCs into their educational ecosystem. It might be true to say that online educational resources (OERs) re-invented themselves in the face of MOOCs over technological advancements and MOOCs now have the power to serve as a frugal solution to resource scarce educational environments where students don't have access to quality educational systems.

Affordability constraint is another factor that hinders the access of quality higher education services to students living in rural areas or tier 2 and 3 cities. Even in the current age of digitization and internet 4.0 it is absolutely not necessary in the developing and under-developed countries that underprivileged students could even afford the basic fee for MOOCs available on for-profit online platforms such as Udemy®, Edx® or Coursera®. As lucrative as they might sound but paying for such courses might not resonate with their actual needs. Thus, MOOCs which are entirely free of cost have massive potential to bridge this gap in the same way Indian car manufacturer TATA® with their Nano® car did as one of the most successful frugal innovations in the

automobile sector by bringing the luxury of owning a car to the common man (Rao 2013). To put the matter into an Indian perspective the exponential growth of a government run platform SWAYAM® (self-induced) is currently being used by students absolutely free of cost. All the courses are freely accessible which has led to the huge number of student enrolments across multiple domains from all parts of the country. Since the courses are made by lecturers from the top institutions in the country the appeal is much stronger and encouraging. Thus, the second step for banking upon the power of frugality is to make sure affordability is not a constraint on any level for any student.

Accessibility constraint is one that is based under the context of resource scarcity. According to (Horn et al. 2013) for an innovation to be considered as frugal, it has to be accessible by the masses and not restricted to a particular niche of the society. A student with a good enough internet connection can access MOOCs from any part of the world. But, good enough is a relative term and could be probed under the aegis of resource scarce environments where access to high speed internet might not be that easy. The video sessions for MOOCs which are broadcasted live require high speed internet connection and according to Roser, Ritchie and Ortiz-Ospina (2020) access to internet services in the world is still skewed on one side of the scale. In the Indian scenario the government is spending huge amounts of money via local schemes such as 'BharatNet' to make sure internet access is easy for villages and remote areas ("Vikaspedia Domains" 2016). It is an attempt to connect local villages with government schemes aimed at improving e-governance, e-banking, e-health and e-education. Therefore, improving accessibility to internet services is equally important for frugal innovations to thrive in the backdrop of establishing frugal MOOCs.

Finally, the relationship between innovation, frugal innovation and MOOCs could be summed up in the form of similarities depicted in the three concepts (see Figure 1).

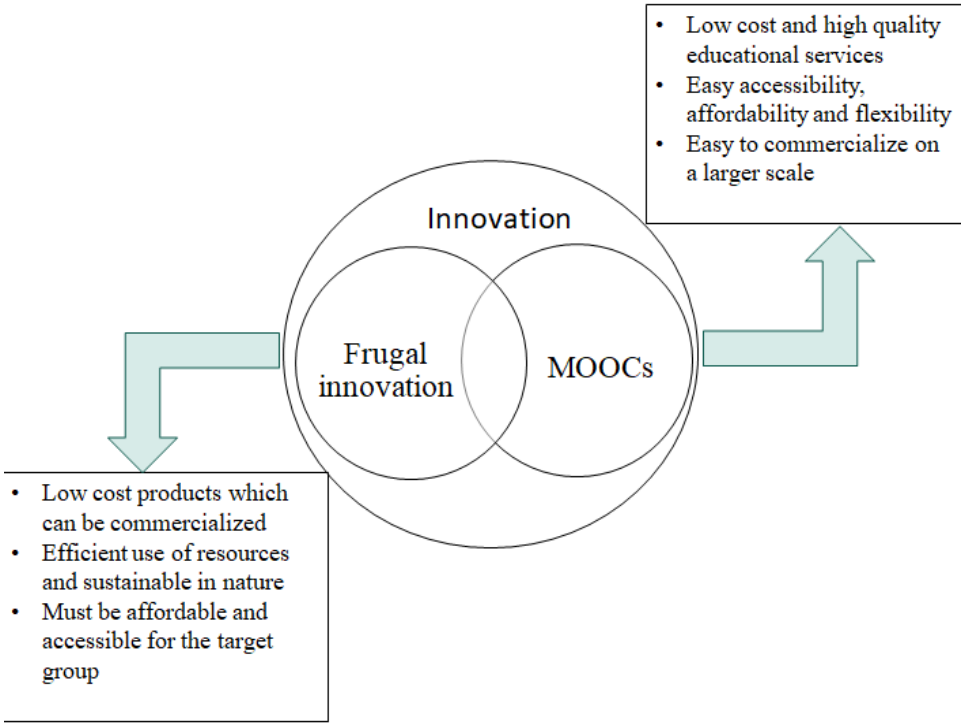

Figure 1. Relationship between innovation, MOOCs and frugal innovation

RESULTS AND DISCUSSION

Once the review of definitions was done, it was necessary to vet our findings from users/experts in both the fields and understand how one can optimally make use of the frugal characteristics of MOOCs. We conducted semi-structured interviews with a group of lecturers from a technical university where a choice based credit system for MOOCs is embedded in undergraduate (UG) degree programme curriculum. A focused group interview was also conducted with grass root frugal innovators (teachers) in primary education in rural areas why? Because, these teachers work in some of the most remote areas of the country and face numerous challenges due to lack of resources (capital, labour and technological) pushing them to perform acts of frugality in their everyday lives. Some of the excerpts from the commentaries of various experts in both fields are mentioned below:

Opinion of Primary school teachers: "We have to perform 'jugaad' in our day to day lives due to resource constraints from the government. To run an institution various resources are needed but we have to eventually manage with little at hand (see figure 2). For example, we are teaching students to become self-sufficient and embed values of sustainability in them. These children come from the marginalized sections of the society and we teach them how to improvise for daily challenges. We don't have text books to be distributed to all the students for primary education so; we have devised a method of teaching basic numeracy skills by changing our teaching pedagogy and all inclusive participatory learning etc."

In developing countries such as Guatemala, Philippines, Bolivia etc. access to internet is still considered as a luxury in rural areas (Istance et al. 2019). In rural India there is only (21.2%) access to computers in primary and secondary (ASER Centre 2018) schools. Reports have shown that almost half of primary school (5th grade) students can't read or write properly in India and one of the worlds' biggest educational systems is facing a learning crisis (ASER Centre 2018). During our visit, it was not startling to see that there was a lack of resources in rural areas, but what were more important to note from our experience was teachers' willingness and a pro-active approach to sensitize the stalled education system with change. Our interviewees considered themselves duty bound ethically and morally to teach and up-skill the students by simple acts of frugality. Therefore, for such education systems where the government leadership and policy making is consuming much more time than needed teachers could use OERs and MOOCs to suffice the immediate needs of the students. Further, we also introduced the teachers to online learning platforms (see figure 3) Khan Academy® (US) and Byjus® (India) and asked them if they can supplement their teaching with high quality learning material from these platforms for faster, efficient and up-to-date growth of the children. However, at the current stage, it is hard to measure how efficient these interventions would prove to be in the long run since lack of awareness and support from competent authorities might dilute their motivation to appreciate the power of frugality underlying OERs and MOOCs.

Opinions of academicians on frugal nature of MOOCs in higher education: "[...] I do acknowledge the presence of an inherent power of frugality in MOOCs but there is major lack of awareness amongst academicians in higher education regarding its feasibility and effectiveness in our country which is clouded by the rudimentary ideologies of higher authorities"

Figure 2. Students engaged via participatory learning and role play as street vendors during authors' visit at a primary school (Nhu district, Haryana, India, February 10, 2022).

Figure 3. Teacher acquainting students with online learning platforms for grades 1-5 via Khan Academy® and Byjus® apps on mobile phone during authors' visit at a primary school (Nhu district, Haryana, India, February 10, 2022).

"[...] By virtue of definition MOOCs might be called as frugal innovation since there are institutions which lack resources in our country. MOOCs can aid these institutions in providing quality higher education anytime at their disposal"

"[...] As, understood from the definitions, frugality is a mindset which means doing something more efficiently with limited resources and constraints. There is a major issue of skill-gap in our country and quality education is lacking in major domains thus, the students who cannot access or afford quality higher education can make use of the MOOCs model to up-skill themselves but proper guidance is a must"

It was evident from our discussions that the same awareness gap and lack of leadership that drags the growth of students in primary education lingers on in higher education as well. The power had predominantly been dormant in nature due to lack of attention and trust in MOOCs models for disseminating quality education. Hence, a niche of students' accessing MOOCs is rapidly evolving majorly in tier-1 institutions and cities and not across the rest of the country. In words of Stephen Downes one of the co-founders of MOOCs, sharp criticism of the rapidly evolving MOOCs system as a for-profit business model could be heard in an interview (Downes, 2012) where he explicitly said:

" [...] I don't see how you can call something open and charge money for it, I am sorry those two concepts to me just don't down go together in the same sentence"

It is in nature of every system to evolve and mould itself according to the decisions taken by its key players. In the case of MOOCs the platforms such as Coursera®, Edx® and Udemy® etc. are charging a fee for earning certification of a course but, what value are these if a particular student segment can't afford them? Should we not debate about the acceptability of these certificates in various job markets? Why only the students from top institutions and tier-1 cities in the country are accessing MOOCs rapidly? The majority of the courses on these platforms have options for a paid certificate and the misconception around the word 'open' in MOOCs is now beginning to clear. Thus, the marketing and selling of 'education' as an online product is beginning to penetrate the upper layers of MOOCs. In coming years it would not be dramatic to view these online courses and certifications "on happy hour" sales or "1+1" offers. We are not counter arguing the business models of these platforms and MOOCs are definitely accessible to anyone with an internet connection but, we argue that the real value will not trickle down on its own until and unless students are guided by teachers and their institutions are financially aided by the government in such countries. Thus, Institutional and governmental interventions are a must for MOOCs to co-exist between all divisions of a society in an unbiased manner.

HEIs are not devoid of resources needed to exploit the potential of MOOCs but in order to maximize efficiency they must play an active role in developing networks with partnering institutions, prospective employers and the government. It is necessary for institutions to develop policies that communicate the benefits of MOOCs in a way, that doesn't disrupt or undermine the current educational systems in place. It is important to understand the needs of the market not only on a national level but also on a global level for appropriate student guidance and support. It is the right time to bank upon the frugal power of MOOCs i.e. easy accessibility and affordability for supplementing educational environments with high quality e-learning certifications and courses via a connectivist mode of learning. It will empower institutions to get connected with the national and global education systems which have progressed substantially in proliferating MOOCs on various platforms. Thus, it is altogether more crucial for underdeveloped higher education systems to embrace the MOOCs model with a frugal mindset. For example, the higher education systems across the globe have

recently shown exemplary behaviour in the darkness of the ongoing pandemic COVID-19. Around the globe multiple HEIs have moved towards the use of MOOCs and online education platforms to aid their stalled educational systems (Mineo 2020). Since free e-content knows no boundaries, voices from all education systems are being heard across top global universities which have opened access to free learning for students across the globe. During these crucial times live online learning has emerged as a potent tool to tackle problems of disseminating knowledge and learning activities (Burgess et al. 2020). Thus, the situation has been a blessing in disguise for all educational systems that were not globally connected and lacked sophisticated tools and technologies by pushing them to become more frugal in using e-resources for accessing quality higher education.

CONCLUSION

On a very primary level of elucidation after thorough textual analysis we have observed that 'any form of innovation be it new or induced after changes in the existing structure of products or services for the better good of masses be them poor or rich can be defined as frugal innovation'. MOOCs don't fail to identify themselves as a form of frugal innovation on tracks of low cost educational services targeted at students who either have marginal access to study resources or limited affordability to quality higher education. The only promising way of realising the hidden potential of MOOCs is by unleashing the power of frugality which prerequisites a certain degree of philanthropic and visionary mindset on part of partnering HEIs, MOOCs offering platforms and the government. In context of developing countries primary issues such as, lack of awareness amongst academia, over-reliance on orthodox teaching pedagogies and stagnant curriculum across majority of HEIs needs to be revamped first by corroborative efforts of top institutions and the government. Only with efficient policy interventions, the issues of access to quality higher education and reduction of skill gaps arising due to lack of knowledge could be addressed with the help of MOOCs. Since, MOOCs are low cost educational services we vouch for government and HEIs support in aiding students deprived of quality education primarily due to financial constraints. Whilst looking at the higher education systems at large, the need for private players offering online platforms for the culmination of e-resources should not be sidelined. Our study is not against the commercialization of education; that has already happened long ago and will continue to flourish with changes and advancements in technologies. But, we aim to spread a message for an integrated approach which reduces the burden on HEIs for churning out individuals who are highly skilled, self sufficient and job ready for a disruptive global context.

Limitations and future research: Even though with all of our best knowledge and experience put to test, we believe our study might be limited by the subjective interpretations of select definitions. Additionally, we have selected limited research articles for the review and we might have had missed out on a few good papers. Techniques such as text mining via tools such as R-Studio® or Python® could also be used to analyse a greater number of papers depending upon the feasibility of the study. Since, frugal innovation is not appropriately researched in the education sector we leave it up to the research community to corroborate our findings and look for patterns of frugality in the education sector.

As of now we have highlighted the implicit determinants of frugal innovation and their relation with MOOCs but, we would also like to propose a conceptual model which is in its testing phase. Explanation of the model is not within the scope of the present study rather a brief overview is provided (see figure 4). We are primarily concerned about the efficient integration and acceptance of MOOCs into the HE systems of developing and underdeveloped countries which are plagued with several institutional and human-induced biases. Literature apprises that the three independent variables represent the basic nature of frugal innovation and we believe they might have a direct and substantial bearing on effective integration of MOOCs into such higher education systems. To actually benefit from the frugal power of MOOCs one must delve deeper into the reasons and degree of affect the aforementioned constraints have on such form of unification such that, effective policy making and guided decisions could be made.

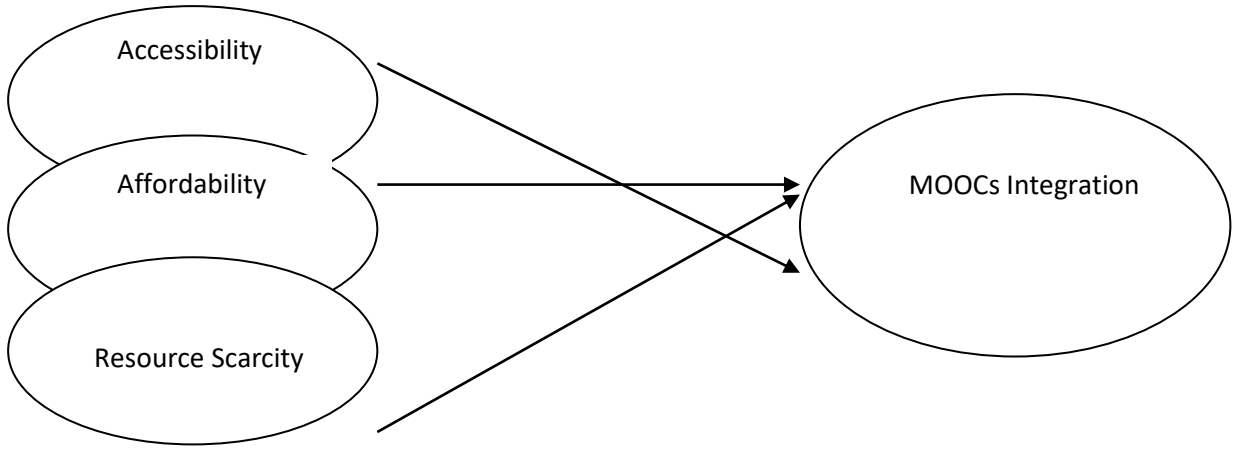

Figure 4: Conceptual framework for frugal MOOCs

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Appendix A

Sample definitions from papers reviewed on Frugal Innovation

Authors	Definition or features (in-text)	Article Title	Year	Cited by*
(Zeschky, Widenmayer & Gassmann , 2014)	....In contrast to good-enough innovations, frugal innovations are not re-engineered solutions but products or services developed for very specific applications in resource constrained environments.	From cost to frugal and reverse innovation: Mapping the field and implications for global competitiveness	2014	87
(Ray & Kanta Ray, 2011)	....a deliberate and singular focus on frugal use of technology and resources is required for crafting a disruptive technology that provides basic functionalities at a very low price.	Product innovation for the peoples car in an emerging economy	2011	83
(Sharma & Iyer, 2012)	... frugal-innovations possessing a no frills structure have been developed for the thrifty consumer under constraints of developing countries. ... The adoption of frugality entails design principles that advocate minimal use of resources for realizing efficient functioning of products.	Resource-constrained product development: Implications for green marketing and green supply chains	2012	78
(Prabhu & Jain, 2015)	....Frugality refers to the ingenious use of limited resources at hand.... Flexibility alludes to the ability to rapidly adapt and improvise to changing circumstances. And finally inclusivity involves developing goods and services for individuals and communities who are significantly constrained in their capacity to pay and are often marginal participants in the market-based economy.	Innovation and entrepreneurship in India: Understanding jugaad	2015	57
(Brem & Wolfram, 2014)	....For frugal innovation, the BoP is seen as a potential market where sales might be gained and new competition arises. The frugal innovation approach is predominantly product-oriented to cut costs for materials or processes through frugality and simplicity that includes, partially, an ecological idea	Research and development from the bottom up - introduction of terminologies for new product development in emerging markets	2014	54
(Rosca, Arnold & Bendul, 2017)	....As such, frugal innovations do not only involve new technologies, but also innovative ways of altering traditional value creation and capture mechanisms through value chain elements reconfiguration, business models reshaping, re-engineered products and services, inclusion of poor into the economic markets and extreme focus on affordability constraints.	Business models for sustainable innovation – an empirical analysis of frugal products and services	2017	44
(Tiwari & Herstatt, 2012)	....frugal product innovations, as shown by the examples above, may require complex and concerted research & development (R&D) efforts to design an easy-to-use, low-cost solution to a complex problem.	Assessing India's lead market potential for cost-effective innovations	2012	44
(Agnihotri, 2014)	....Frugal innovation refers to those innovative products and services which are developed under conditions of resource constraints.	Low-cost innovation in emerging markets	2015	38
(Pansera & Sarkar, 2016)	.... "frugal innovation", i.e., the search for simple but effective solutions to deliver affordable products/services.	Crafting sustainable development solutions: Frugal innovations of grassroots entrepreneurs	2016	36
(Soni & T. Krishnan, 2014)	....The process through which this is done is often referred to as "frugal engineering", and the outcome, which are generally low-cost, good-enough products or services, are known as "frugal innovations".	Frugal innovation: Aligning theory, practice, and public policy	2014	36

(Lim, Han & Ito, 2013)	....Here, the product innovation for the ULM can be considered as 'frugal' or 'Ghandian innovation', in that the product has to bear resource-saving product for low income consumers.	Capability building through innovation for unserved lower end mega markets	2013	31
(Hossain, Simula & Halme, 2016)	....that frugal innovation refers to products, services or combination of them that are affordable, sustainable, easy-to-use, and have been innovated under the resource scarcity.	Can frugal go global? Diffusion patterns of frugal innovations	2016	27
(Horn & Brem, 2013)	....The concept of frugal innovation aims at modifying and adopting products to foreign, emerging markets on the one hand, and the establishment of R&D capacity and product development centers on the other hand..... ....Frugality postulates a concept of products being easier to produce and be more adapted to the use of consumers in emerging economies.	Strategic directions on innovation management - a conceptual framework	2013	27
(Levvnen et al., 2016)	....It refers to solutions created under the circumstances of resource constraints.	Implications of frugal innovations on sustainable development: Evaluating water and energy innovations	2016	23
(Khan, 2016)	.....Frugal innovation is developed in severe resource constraints; it involves good quality and reasonably priced products or services even for the customers with modest lifestyles. ....Generally, frugal innovation is viewed as low cost innovation but it is much more than that. Frugal innovation uses the concept of simplification and strives for less instead of more by using clever technology.	How frugal innovation promotes social sustainability	2016	22
(Winterhalter, Zeschky, Neumann & Gassmann, 2017)	....frugal mindset represents the creation of very high customer value at very low costs for resource-constrained people in emerging markets.	Business Models for Frugal Innovation in Emerging Markets: The Case of the Medical Device and Laboratory Equipment Industry	2017	19
(Gupta et al., 2016)	...The frugality (or low-cost, affordable nature of innovations) emerged as an inalienable feature of grassroots innovations. ...frugality must blend affordability with circularity (the ability of waste being repurposed, recycled or incorporated in different value chains without affecting the environment adversely).	Theory of open inclusive innovation for reciprocal, responsive and respectful outcomes: Coping creatively with climatic and institutional risks	2016	17

*At the time of extraction from SCOPUS® database

Sample definitions from papers reviewed on MOOCs

Authors	Definition or features (in-text)	Article Title	Year	Cited by*
(Liyanagunawardena, Adams & Williams, 2012)	....Connectivity through freely accessible online resources	MOOCs: A systematic study of the published literature 2008-2012	2013	485
(Jordan, 2014)	....Free courses from a range of elite universities	Initial trends in enrolment and completion of massive open online courses	2014	370
(Martin, 2012)	....No fees for courses, large scale applicability	Education will massive open online courses change how we teach	2012	188
(Alraimi, Zo & Ciganek, 2015)	....Free online classes open to all	Understanding the MOOCs continuance: The role of openness and reputation	2015	165
(Littlejohn, Hood, Milligan & Mustain, 2016)	....MOOCs emphasise their openness and scale, which allow learners, regardless of location or previous experience and qualification, to engage at no (or minimal) cost in learning opportunities, which often are curated by leading universities.	Learning in MOOCs: Motivations and self-regulated learning in MOOCs	2016	147
(Hone & El Said, 2016)	....Massive Open Online Courses (MOOCs) are a rapidly growing mode of educational provision, holding the potential to open up access to world class teaching and educational resources beyond geographical and social boundaries.	Exploring the factors affecting MOOC retention: A survey study	2016	146
(DeBoer, Ho, Stump & Breslow, 2014)	....MOOCs are online learning environments that feature course like experiences—for example, lectures, labs, discussions, and assessments—for little to no cost	Changing "Course": Reconceptualizing Educational Variables for Massive Open Online Courses	2014	139
(Kaplan & Haenlein, 2016)	....A MOOC is an open-access online course (i.e., without specific participation restrictions) that allows for unlimited (massive) participation.	Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster	2016	132
(Kay, Reimann, Diebold & Kummerfeld, 2013)	....They're *open,* meaning that anyone can use them to learn. This also logically implies that they're free, removing any financial barrier for even the poorest student.	MOOCs: So many learners, so much potential.	2013	128
(Wu & Chen, 2017)	....The advantages of MOOCs are large scale, openness and self-organization. MOOCs enable students to access free and open education provided by the most reputable universities, which attract substantially larger audiences than traditional online education.	Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model	2017	127
(DeWaard et al., 2011)	....It is our belief that the MOOC format allows massive participation leading to the creation of possible educational futures.	Using mLearning and MOOCs to understand chaos, emergence, and complexity in education	2011	117
(Glance, Forsey & Riley, 2013)	....What is new is the numbers of participants, and the fact that the format concentrates on short form videos, automated or peer/self–assessment, forums and ultimately open content from a representation of the world's leading higher educational institutions.	The pedagogical foundations of massive open online courses	2013	108

(Ebben & Murphy, 2014)	....Today's MOOCs are internet-provided courses, open to anyone with web access, typically free of charge with no penalties for non-participation.	Unpacking MOOC scholarly discourse: A review of nascent MOOC scholarship	2014	101
(Baggaley, 2013)	....MOOCs tend to be simpler and more impersonal than previous forms of online education: no teachers; no supervision; no fees nor entry requirements; the only equipment required being the computers purchased by the students; thousands of students in a single course; students teaching each other; students grading each others' work.	MOOC rampant	2013	100
(Barak, Watted & Haick, 2016)	....Massive open online courses (MOOCs) provide people from all over the world the opportunity to expand their education for free without any commitment or prior requirements.	Motivation to learn in massive open online courses: Examining aspects of language and social engagement	2016	99
(Gillani & Eynon, 2014)	....MOOCs are hybrids of previous attempts at online distance education: they bring together early approaches to online learning and the scale and potential reach of open courseware efforts.	Communication patterns in massively open online courses	2014	98

*At the time of data extraction from SCOPUS® database