

ARTICLE

Placing Students at the Heart of the Iron Triangle and the Interaction Equivalence Theorem Models

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A number of visual models have been proposed to help explain the interplay and interactions between specified components of higher education systems at different levels and to take account of emerging trends towards open education systems. At sector and institutional levels the notion of an iron triangle has been posited, linking firstly access, quality and cost and latterly accessibility, quality and efficiency in order to suggest means for widening access to higher education for the same or lower cost without compromising outcomes. At the level of teaching and learning an interaction equivalence theorem was developed to explain the relative contributions to successful study of teachers, students and educational content in formal settings and which has recently been extended to informal settings. However both models deal mainly with the supply side of the educational systems they attempt to represent, namely impacts of the availability and accessibility to more people of the elements in the models, and largely ignore the demand side in terms of the affordability and acceptability of the available and accessible provision to students and learners alike. Further, while stimulating debate there has to date been limited empirical studies undertaken to validate both these models. Despite this lack of testing, this paper explores ways of extending these existing models both visually and conceptually by adding in the perspective of the prospective learner or student in respect to their organisational capacity to invest sufficient time for studying, the levels of preparedness and/or confidence that they hold before they engage in learning and the level of motivation for undertaking those studies. It is argued that these modified models provide a new contextual framework with which to examine the capacity of more open education systems at the national, institutional and individual learner level to be expanded effectively and equitably. It is hoped that these extended models provide a new basis for undertaking empirical studies to test out the underlying assumptions.

Keywords: open educational resources; iron triangle; interaction equivalence theorem; diagrams; engagement; education systems

Introduction

There are many socio-economic factors involved in the demand for and engagement with higher education in general (e.g. Oxford Economics, 2014), and open education in particular (Lane, 2013a); which can make it difficult to understand and predict the individual and collective impacts of those factors. However, it is widely believed that greater participation rates in higher education impact upon the social and economic performance of nations. An OECD (2006) report is clear about the benefits of educational attainment:

A well-educated and well-trained population is important for the social and economic well-being of countries and individuals. Education plays a key role in providing individuals with the knowledge, skills

and competencies to participate effectively in society and the economy. Education also contributes to an expansion of scientific and cultural knowledge. The level of educational attainment of the population is a commonly used proxy for the stock of "human capital" that uses the skills available in the population. (p7)

At the same time there is significant debate over the nature of teaching within higher education created by the increasing provision of, and seemingly demand for, online education and open education (e.g. Ilyoshi and Kumar, 2008). These debates touch upon how students might learn, how teachers could teach and what role educational content plays in both those processes.

The complexity of these systems leads many to try and represent the key factors involved to focus discussions and actions. A number of visual models have been proposed to help explain the interplay and interactions between specified components of higher education systems at different

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levels and to take account of the emerging trends towards more open education systems involving open entry, open educational resources (OER) and Massive Open Online Courses (MOOCs). As with many such visual models they are there to reinforce or help explain an argument or conceptual logic, but can equally conceal as much as they reveal unless tested out empirically (Lane, 2002; 2013b). In this paper I look at two major visual models that have been proposed and have gained a degree of attention but have been subject to varying degrees of empirical testing and then add to both of them a greater emphasis on the nature of the student or learner body in order to reveal some hidden assumptions that link them and provide a new perspective to stimulate further debates and decisions on empirical testing. These models are the iron triangle and the interaction equivalence theorem.

The iron triangle model

At sector and institutional levels the notion of an iron triangle for education has been posited, linking firstly access, quality and cost (and latterly accessibility, quality and efficiency) in order to suggest means of using open, distance and e-learning (ODeL) and/or OER for widening access to higher education for the same or lower cost without compromising outcomes (Immerwhar *et al*, 2008; Daniel and Uvalic-Trumbic, 2011; Mulder, 2013). **Figure 1** shows the basic triangle as outlined by Daniel and Uvalic-Trumbic with equal length sides representing the three factors, in this model, of scale, quality and cost. The assumption is that increases in one point of the triangle will inevitably lead to stresses in the other points. This is particularly assumed to be so because of the relatively fixed costs of the physical infrastructure of universities and the number of teachers they employ due to the relatively small cohorts that each teacher can manage to teach successfully (there are many debates worldwide about optimum class sizes and effects on pedagogic quality but the physical limitations of most existing classroom sizes in expensive buildings and their occupancy rates are universal). They go on to visualize changes within this triangle of inter-related factors (**Figure 1-A**).

These changes make the basic point that with conventional teaching in classrooms there is little scope to alter these factors advantageously because improving one factor will worsen the others. Pack more students into the class and quality will be perceived to suffer (**Figure 1-A1**). Equally, try to improve quality by providing more learning materials or better teachers and the overall cost will go up (**Figure 1-A2**). In effect the area under the triangle does not change because of these physical limitations.

From this basic position, Daniel and Uvalic-Trumbic assert that ODeL, because it is not so constrained by physical limits, is able to change the shape and size of the triangle because it can provide quality in the educational experience (e.g. in the educational resources or support structures) at greater scale for a similar or even lower cost than place-based learning. This means giving the learner more flexibility in their studies such that the learner is not constrained to studying in expensive to build and maintain

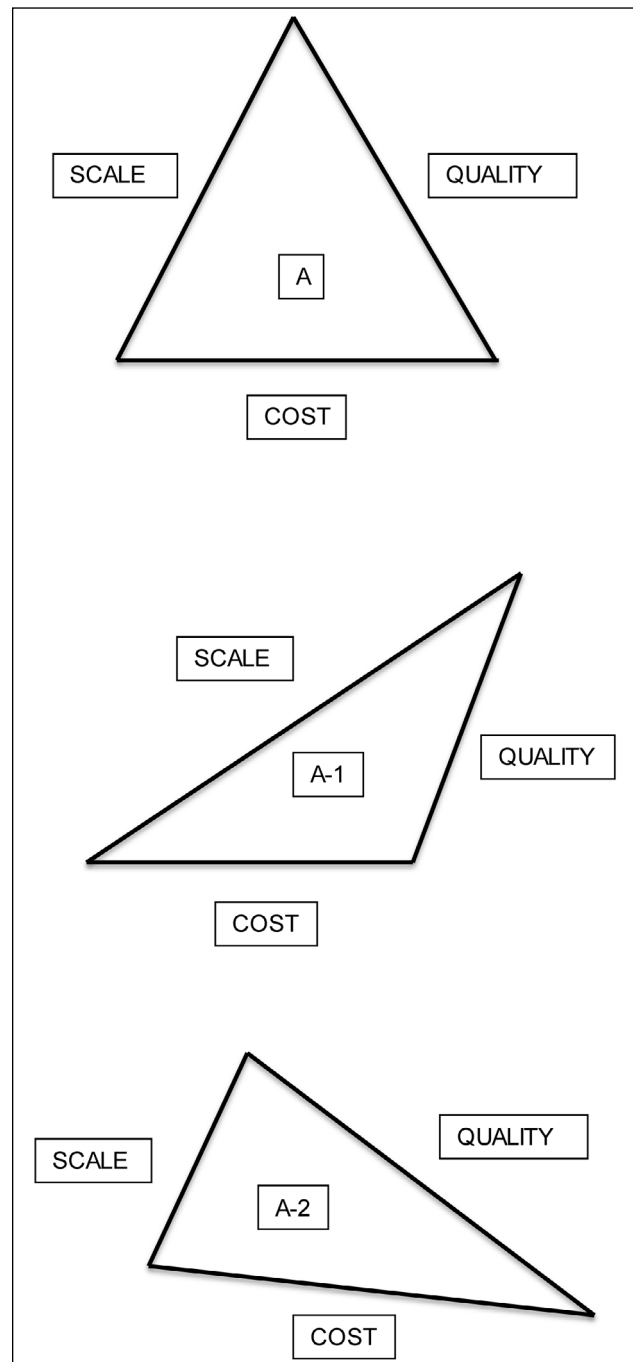


Figure 1: The Iron Triangle of Education.

campuses but where they live and work and where quality can be measured by their achievements and not by exclusivity of access. As Daniel *et al* (2009) conclude:

The aims of wide access, high quality, and low cost are not achievable, even in principle, with traditional models of higher education based on classroom teaching in campus communities. A perception of quality based on exclusivity of access and high expenditure per student is the precise opposite of what is required. One based instead on student achievement enable developing countries to scale up their higher education APRs [age participation rates] without breaking the bank or fatally compromising quality.

Interestingly Mulder (2013) has recently modified this model from a 2-dimensional to a more 3-dimensional one, focussing on the accessibility, quality and efficiency of education as the three factors, the aim for all being maximisation of the factor rather than minimisation as it is for cost in the original model. Mulder also postulates that a radical intervention such as OER, rather than just technology, can end up increasing all three factors and so enlarging the educational space represented by the triangle and thus the increase the numbers of people participating. To quote from Mulder (2013):

Figure 2(a) shows such a 3D representation of the performance of Dutch education at a certain moment with values along the three axes for accessibility, quality, and cost-efficiency. These are interconnected through a three-point plane. Suppose one wants to improve the performance in efficiency. In **Figure 2(b)** we see an example (in red), where indeed cost-efficiency is increasing, however at the cost of both quality and accessibility, which are decreasing. **Figure 2(c)** presents another example where the performance in quality is better, but this goes hand-in-hand with lower cost-efficiency and more or less equal accessibility.

If circumstances and conditions do change, the pattern can look different. A radical system intervention with OER (see **Figure 2(d)**) is an example of an innovation, which can result in simultaneous performance improvement in all three dimensions. Indeed, the accessibility of the learning materials is at a maximum with their full and free online availability. And the quality is being served with OER, because many more experts and users are involved in the development of the learning materials, which moreover are evaluated, corrected, and reviewed. Finally, cost-efficiency is promoted since there is actually no rationale any more for multiple full-scale development of courses on the same subject with similar learning objectives by different educational institutions.

Whichever model is deemed a better representation of national or institutional education systems, the argument they both support is that if a suitable educational system is developed and supplied then increasing numbers of people and proportions of a country's population can be suitably educated at tertiary level. However, while the iron triangle has been used to frame debates there has not been any rigorous testing of these models through either the analysis of secondary data or the collection of primary data, possibly because it is difficult to agree on suitable units of measurement for the different dimensions e.g. quality.

The interaction equivalence theorem model

At the level of teaching and learning within a course, and particularly within ODeL, an interaction equivalence theorem or EQUiv (**Figure 3**) was proposed and developed to explain the relative contributions to successful study of

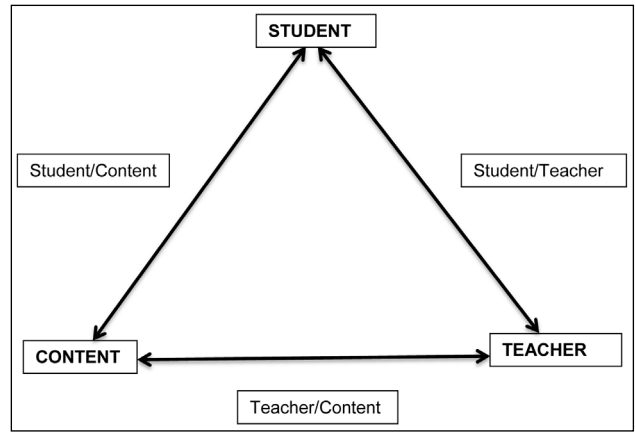


Figure 2: Performance of the Dutch education system along the three axes of accessibility, efficiency and quality (from Mulder, 2013).

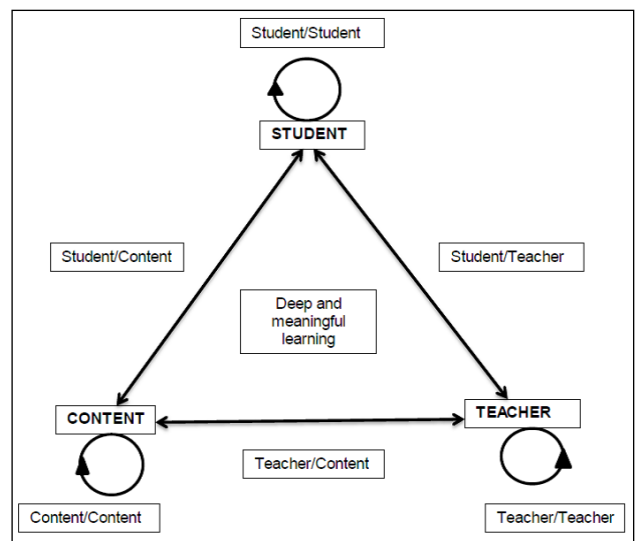


Figure 3: The Interaction Equivalence Theorem.

teachers, students and educational content in formal settings (Anderson, 2003; Miyazoe and Anderson, 2010), and which has recently been extended to informal settings using OER and MOOCs, with passing mention of links to the original iron triangle model (Miyazoe and Anderson, 2013). Building on the original formulation of the primary forms of interaction (student-student; student-teacher; student-content) proposed by Moore (1989) the basic premise of the EQUiv is that:

'... deep and meaningful learning is supported as long as one of the three forms of interaction (student-teacher; student-student; student-content) is at a high level. The other two may be offered at minimal levels, or even eliminated, without degrading the student experience'. (p2).

While there has been much theoretical development of the EQUiv there have not been many empirical studies undertaken to support it for either higher education or wider training. However, a recent doctoral study by

Rodriguez (2014) both surveyed the available literature and found some corroboration of the theorem and also concluded that:

Results showed that course design does not dictate the type of interactions that students use. In corporate settings, an online course can be effective in terms of satisfaction, learning, knowledge transfer, business results and return on expectations, as long as one of three types of interaction (learner-content, learner-teacher or learner-learner) features prominently in the design, and delivery is consistent with the chosen type of interaction. (Abstract)

While this supports the basic triadic model, **Figure 3** shows a lot more than just the interactions between students, teachers and content. It also highlights the relationships between teachers and the content being used; and the fact that teachers interact with other teachers and that content can interact with other content, most notably in the case of dynamic digital content within educational software. I am not going to address these elements in this paper as I intend to focus more on developing a fuller representation of the student side of interaction. In particular I want to explore the implication that, just as with the iron triangle model, the basic interaction equivalence theorem implies that a suitably designed and delivered educational provision will inevitably lead to success by the students involved and that even some failings on the part of the design around interactivity can be compensated for by the other elements.

Supply side versus demand side

While there are more elements to the Equiv models than presented here, and while Miyazoe and Anderson (2013) have also acknowledged that the '*ability to manage the cost and the time for learning is becoming extremely critical to formal students and lifelong learners*' (p11–12), the theorem in itself does not fully address the wider range of capabilities of the prospective learner or student as conditioned by their intrinsic psychological characteristics and their extrinsic socio-economic context and/or status.

A recent review of student satisfaction with interactivity in online learning by Croxton (2014) has examined some of those intrinsic psychosocial characteristics and the role of interactivity and concludes that '*Findings suggest that interactivity is an important component of satisfaction and persistence for online learners, and that preferences for types of online interactivity vary according to type of learner*'. (p314). This indicated the not unexpected finding that students vary in their capacity and capability to engage meaningfully with the educational provision on offer.

As implied earlier, it is often a strategic governmental aim to widen access to and participation in higher education by as large a proportion of the adult population as is reasonably possible (Lane, 2012) to boost social and economic returns. However, when considering the scope for widening participation to people who would not traditionally attend higher education because of low previous

educational attainment or through suffering multiple deprivation it can be useful to consider the availability, accessibility, affordability and acceptability of the provision to learners and their families (ibid). Thus both these models deal mainly with the supply side of the educational systems they attempt to represent, namely impacts of the *availability and accessibility* to more people of the teaching or interaction elements in the models, and largely ignore the demand side in terms of the *affordability and acceptability* of the available and accessible provision to students and learners alike as seen from their own contexts and life experiences. In the next section I attempt to address this deficiency by adding to and modifying these two visual models.

Modifying the models

One of the strengths of diagrammatic models is to test out your thinking – to do some thought experiments that may be supported by existing evidence or that provide suggestions for where further empirical or experimental research could be directed. What follows are my initial attempts at extending the representation of the students' or learners' contexts within the models, focussing on ODeL systems rather than traditional face-to-face educational systems.

Adding a circle of success to the iron triangle

A defining feature of many higher education systems has been one of selecting students based on prior educational experiences and achievements, thus ensuring that they are more likely to be well prepared and confident in the learning abilities (Lane, 2013). Where ODeL has been used then often greater efforts are made to accommodate less advantaged students (Lane, 2012). In extreme cases, such as The Open University UK, there are no formal entry requirements, enabling up to 40% of undergraduate entrants to not have the school level qualifications expected of entrants in other universities (while up to a third already hold a previous higher qualification). However such open entry also means that retention rates are lower, with many fewer not completing either a module or their chosen qualification (Woodley, 2011). Nevertheless, Open University students consistently rate the quality of their education as being very good in both internal and external surveys. Thus while the iron triangle may be expanded, but not broken, by open and distance learning from the perspective of the sector and institution, there are apparently plenty more people to replace the ones that drop out (Woodley, 2011).

This expansion of opportunity does not, in itself, indicate what other measures of success might be, such as from more of a student perspective. To do just that, I have firstly added a 'circle of success' to the iron triangle (**Figure 4-A**) to represent students who participate completing their chosen studies in good standing¹. In this case any changes in the triangle as noted before (e.g. increased cost; a drop in quality; fewer students) will inevitably breach this circle of success (**Figure 4-A1 & 2**), thus representing a lowering of the numbers left in good standing.

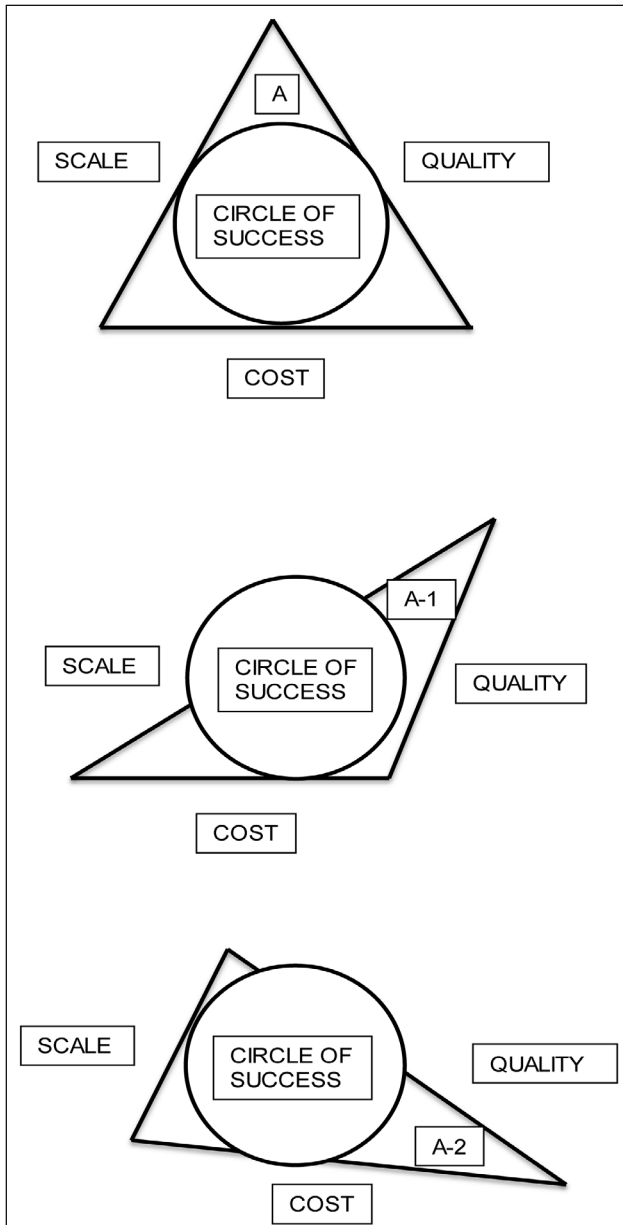


Figure 4: The Iron Triangle and Circle of Success of Education from an Institutional perspective.

A student centred iron triangle

By itself, adding a circle of success does not add much to the existing iron triangle as it is also difficult to see how that dimension could be effectively measured. So for my next step I modified the iron triangle itself to reflect the perspective of the prospective learner or student rather than that of the institution. From my knowledge of the literature around the factors influencing participation in or engagement with higher education (Lane, 2009, 2012) I chose three key factors that might be measurable through surveys, namely their organisational capacity to invest the time required to study, the levels of confidence and/or preparedness that they hold and their motivations for undertaking those studies. It can be reasonably be assumed that increased levels of all of these will benefit the student or learner but also because it is likely that high levels of one factor can compensate for lower levels in the other two. It also implies that if all three are at a low level then the

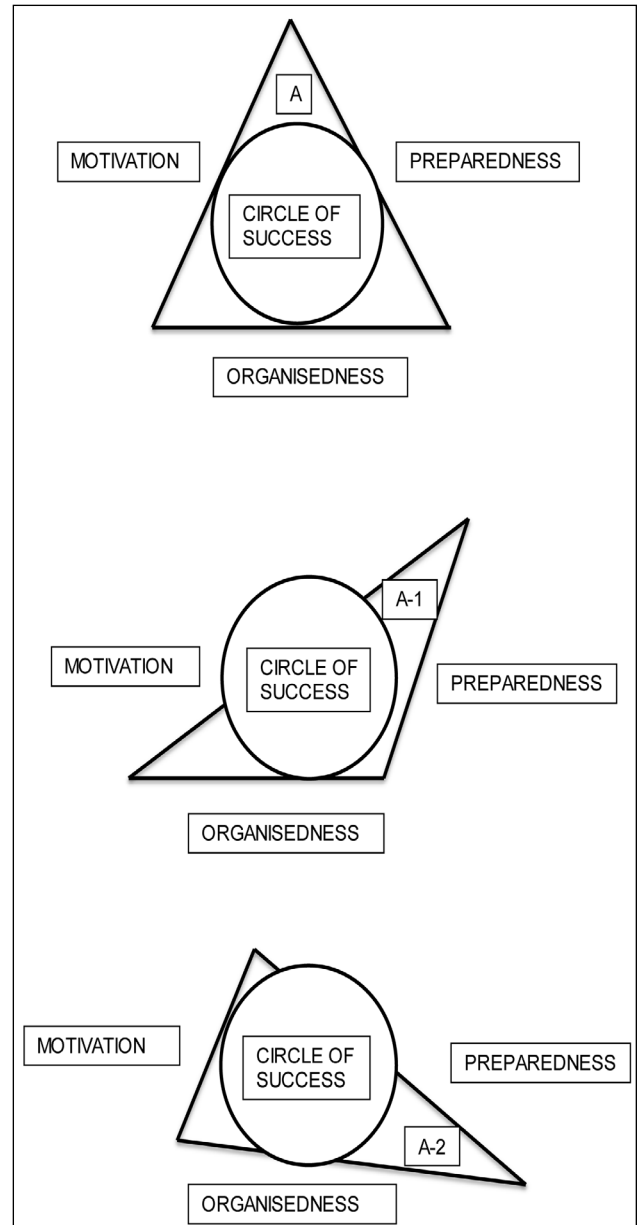


Figure 5: The Iron Triangle and Circle of Success of Education from a Student's perspective.

chances of success in terms of persistence in engagement and levels of attainment will be very low.

This new triangle therefore captures and adds in key aspects of the learners' or students' own context and prior experiences (**Figure 5-A**). And as in **Figure 4** I have also added a circle of success that can easily represent that a student's chances of completing their chosen studies will be compromised if, for example, they are low in preparedness (**figure 5-A1**) or cannot devote sufficient time to their studies (**Figure 5-A2**), but still acknowledging that this is a difficult dimension to measure.

One factor that I have left out is ability to pay financially as opposed to devoting adequate time for the educational provision. Adding this affordability factor in or using it to replace one of the other factors does provide a direct link to the original iron triangle model and just as Mulder (2013) has proposed cost-efficiency rather than cost as the driving factor then affordability could be seen to be

a key factor, but fee levels, bursaries and student loans vary within countries, let alone across countries, making this factor quite complex. For educational institutions the costs associated with their educational provision have to be offset by the returns gained on the investment of time and money involved. It is this issue which dominates the discussions around the sustainability of OER (and now MOOCs). However, many educational institutions, particularly universities, also have broader social missions in which it is not just whether OER might act as a recruitment vehicle for students or reduce costs of developing and delivering educational content but also act as a means of enhancing reputation or visibility. These returns are not direct monetary ones but a social return on investment that adds value to existing activities, particularly in the case of publicly funded educational institutions.

For learners education can similarly provide both economic and social returns on the investment of time and money that they make. As noted at the beginning of the article education provides such benefits in general which is why there is substantive public investment in education systems. But equally the cost, quality and access iron triangle means that expanding access leads to increased costs and increasingly private funding is expected to support this aim, especially for higher education where tuition fees are generally increasing. To justify the increases in tuition fees many governments and other agencies highlight the personal economic returns on education and particularly higher education. This usually relates to improved career prospects and higher lifetime earnings. However, researchers are now trying to widen the debate on returns on investment by trying to estimate the social returns on investment (SROI) for adult education in the UK (Fujiwara, 2012). The key findings of this study are:

Participating in adult learning is found to have significant positive effects on individual health, employability, social relationships, and the likelihood of participating in voluntary work. In turn these domains have positive impacts on individual well being. (p2)

A student centred Interaction Engagement Equivalence Theorem

Such concerns about the likely returns on investment, financial or social, are also likely to impact on how we might view interaction within educational provision. As already noted, just because high levels of content or interaction might be available and accessible does not mean that is affordable (in terms of money or time) or acceptable (if ill prepared or poorly motivated) in which cases the student will be unlikely to engage in deep and meaningful learning but is more likely to engage in shallow and meaningless learning and, at the extreme, ‘drop-out’ or withdraw from the educational system on offer because they are disillusioned and dis-satisfied with the quality or the interactions. To understand this demand side of the education ‘equation’ I propose another model, an interaction engagement equivalence theorem (Figure 6). This

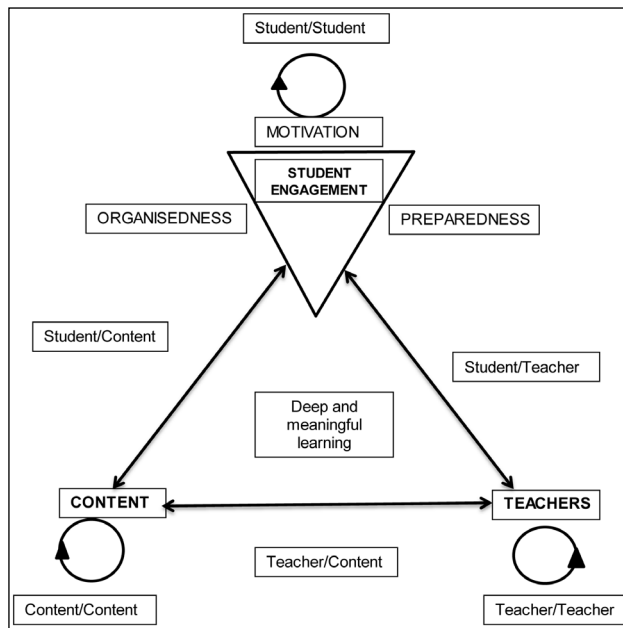


Figure 6: The Interaction Engagement Equivalence Theorem.

replaces the simple notion of a student in the Equiv with the new student centred iron triangle introduced above, changing the assumption of just a student to one of student engagement with the interactions on offer to them. It also aligns the two different sets of equivalences within the same conceptual framework.

Thus, as seen with the earlier model, high levels in one of either motivation, ‘organisedness’², or preparedness on the part of the student for engaging in the educational interactions on offer to them can offset lower levels in the others. For example, a highly motivated person with no previous qualifications and few study skills can succeed if they are able to engage fully with such study skills through the learning design and other support interventions. However if all three engagement factors are low then successful learning is also likely to be low, whatever the learning design and whatever efforts are put in by others to support and encourage greater engagement with their studies.

Interestingly, Croxton (2014) concluded from her literature review that ‘Student-instructor interaction was also noted to be a primary variable in online student satisfaction and persistence’ while Rodriguez concluded that delivery of the provision has to match the chosen type of interaction involved, suggesting that well thought through learning design and delivery are likely to improve success with online learning and/or open education. In that respect, the ideas represented in these extended models could also be applied to the teacher and content parts of the basic triadic model – but that is beyond the scope of this article.

Discussion

There is much debate as to whether and how OER and/or MOOCs will provide cheaper and more scalable solutions to increasing participation rates in higher education compared to the current face to face or ODeL solutions available from higher educational institutions. A logical

examination of the iron triangle model indicates that a hidden constraint is the capabilities of the student. So, even if it is possible to increase one factor, such as a lower unit cost per student, as has been possible with ODeL and could be even more so with MOOCs, it may not increase successful student participation owing to lack of motivation or preparedness on the part of additional students from non-traditional backgrounds. This may also help explain why most MOOC participants that 'complete' their courses do not apparently lack preparedness, motivation or organisedness as implied in the findings of many MOOC studies to date.

The Interaction Equivalency Theorem model highlights the significance of high levels of interaction for successful learning but it also ignores the capabilities of the students to be able to engage with those interactions. The creation of an Interaction Engagement Equivalence Theorem visual model highlights once more that increases in OER and MOOCs, or even e-learning within formal education, may not in itself increase meaningful learning without these engagement issues being addressed by some means or other.

This paper argues that neither the iron triangle or interaction equivalence theorem model adequately reflects the influence that learners' personal attributes and circumstances have on the phenomena that they are trying to account for. Through the thought experiments embodied in the revised models described above, it also argues that to support and increase the level of successful engagement and attainment by less privileged learners requires the use of extended visual models that addresses many of the tensions and opposing forces inherent in these two models.

The modified visual models presented here provide a revised conceptual framework with which to examine the capacity of more open education systems at the national, institutional and individual learner level to be expanded effectively and equitably. They also indicate that such models need to be rigorously tested and evaluated against the particular contexts to which they might be applied. The challenge now is to gather and analyse secondary and primary data that can be used to either validate these models or suggest further modifications, and in particular to focus on their contributions to widening access to and success within higher education.

Notes

- ¹ There are separate debates to be had about what constitutes participation, completion and good standing both within formal courses and also informal MOOCs or OERs.
- ² I use this term rather than organisation to imply it is a property of the student and one that can be difficult to change

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