

# ENGINEERING OF HIGHER EDUCATION SYSTEMS

## HIGHER EDUCATION AS A SOCIAL SYSTEM

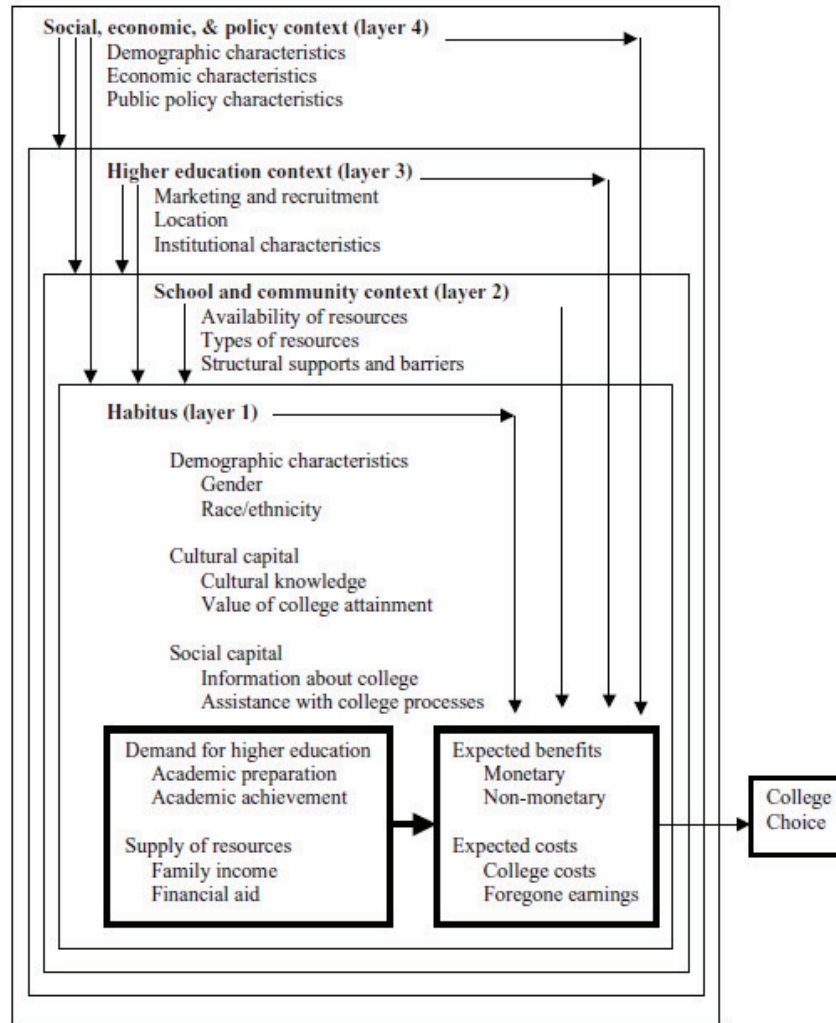
Higher Education (HE) is an entity that is composed of a set of interrelated actors such as universities, institutions, students, and teachers; these actors and the interactions between them compose a system whose whole functioning, then, cannot be divided into independent parts.<sup>1</sup> HE is classified as a social system because both the whole and its constituent parts have purposes of their own in contrast to other systems, such as machines in which neither the whole nor the parts have a purpose or preferences.<sup>2</sup> If we appreciate the incessant decisions, actions and further reactions of those actors then we can see that social systems are human constructs that behave and evolve as a product of the actions that result from the purposes, interests and values of their multiple creators<sup>3</sup> and from the mutual interdependence with the environment. Thus “each social systems is complex, messy, and unique with its own singular accumulate history, [...]; above all, it is created and realized by the very same people who form it with every decision that they make”.<sup>4</sup>

Therefore, a *system* approach to HE requires to address the continuous interactions that constantly re-create such a system and demarcate it as a whole. Furthermore, the design and transformation of such systems imply the intervention in the very decision-processes that create the constitutive relationships of the system.<sup>4</sup> However, we observe that the term “system” is commonly used to refer to Higher Education without the full implications of such a term, which then becomes a mere label. We will illustrate this idea with a key problem: access to education.

## HIGHER EDUCATION AS A MACHINE

Access to HE is a persistent worldwide problem. A great number of studies and papers are published on this subject. For instance, several studies look at the relation between enrollment and characteristics of individuals such as gender,<sup>5,6</sup> parental schooling<sup>7</sup>, race/ethnicity,<sup>8,9</sup> high school academic achievement<sup>10</sup> and family income;<sup>11-14</sup> numerous quantitative studies focus on the effects of finances<sup>15-19</sup> (e.g. tuition, fees, books, financial aid, and socio economic status) on enrollment. On the other hand, sociological approaches concentrate on examine the ways in which context<sup>20-23</sup> and socioeconomic background,<sup>24</sup> affect enrollment, studying aspects such as social capital<sup>25,26</sup> (e.g., assistance with college processes) and cultural capital (e.g., value of college attainment).<sup>27,28</sup>

This literature reveals the predisposition of researches to study the HE system by parts separately (e.g. students, parents, institutions, and context). The study of Perna<sup>29</sup> shows such situation; in her extensive review of research on HE access, she states that neither qualitative nor quantitative approaches considered separately are sufficient for understanding differences in access to HE. This author proposes a conceptual model to integrate aspects of both approaches and suggests that college enrollment decisions are shaped by four contextual layers (See **Figure 1**).



**Figure 1.** Proposed conceptual model of student college choice<sup>29</sup>

Although this model incorporates information of different parts of the system, it is not a system approach. This model proposes relationships in one direction only (upper layers affect lower ones), overlooking the two-way nature of this interactions. For example, the model shows an influence of the HE context (layer 3) to school and community context (layer 2) but no influence from the latter to the HE context. Likewise, the model ignores the relationship between college enrollment decisions and elements of all layers such as: social and cultural capital in the habitus layer, structural support and types of resources in school and community layer, institutional decisions in the HE layer and economic characteristics of context in the last layer. On the other hand, relationships between elements within the same layer are also excluded; for instance, marketing and recruitment of HE institutions affect and are affected by institutional characteristics (layer 3).

This model assumes HE systems as a mechanism consisting of an assembly of uniform parts, each of which draw in invariant tasks and whose behavior is determined by causal laws. This rationality contradicts the free decision-makers nature of parts in social systems, since it does not take into account that “every decision is responsive to the existing condition of the system and influences that

condition”.<sup>30</sup> Indeed, the capacity of parts of HE systems to transform the world (“Agency”) is excluded.

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In contrast, we can understand HE as the product of its operations (actions of free actors), instead of a mysterious repetition of data furnished by law-like principles waiting to be discovered.<sup>31</sup> This type of thinking can be called “operational thinking”, which refers to thinking in terms of “how things really work”, as opposed to how they theoretically work.<sup>32</sup> This operational thinking (know-how) is a distinctive aspect of engineering knowledge that aspire to design solutions to real-world, contingent, problems.<sup>33</sup> Design is a defining characteristic of engineering<sup>34,35</sup> that refers to human artifice: we, as human being designers, adapt means to preconceived ends.<sup>36</sup> Artifacts are man-made objects created for a purpose such as machines, industrial processes and social organizations.<sup>37</sup> HE systems are a fine example of such artificial creations that are designed and redesigned to accomplish diverse purposes.

From this engineering approach, design of effective policies to guarantee access to HE requires an operational understanding of how differences in school enrollments are generated by *agency* of multiple actors, that is, an “intricate complex of decision processes continuously carried out by interacting free actors”.<sup>31</sup> Design involves the multiple elements that confluence in enrollment decisions and their changes throughout time as a result of interactions within system. This conception and understanding of HE as a whole includes elements related to students (e.g. academic skills, socio-economic situation, and preferences), to institutions of HE (e.g., programs, admission policies, tuitions), to government and to context (e.g. social and cultural capital) with the aim of designing new configurations and arrangements of decision-making processes. This is what we call “*engineering of HE systems*”.

## REFERENCES

- 1 Ackoff, R. L. & Gharajedaghi, J. Reflections on systems and their models. *Systems Research* **13**, 13-23, doi:10.1002/(sici)1099-1735(199603)13:1<13::aid-sres66>3.0.co;2-o (1996).
- 2 Ackoff, R. L. Systems thinking and thinking systems. *System Dynamics Review* **10**, 175-188, doi:10.1002/sdr.4260100206 (1994).
- 3 Jenks, C. L. The well-being of social systems. *Systems Research and Behavioral Science* **21**, 209-217, doi:10.1002/sres.616 (2004).
- 4 Olaya, C. in *Systemic Management for Intelligent Organizations: Concepts, Model-Based Approaches, and Applications* (eds S. Grösser & R. Zeier) (In press: Springer, 2012).
- 5 Sahni, R. & Shankar, V. K. Girls' higher education in India on the road to inclusiveness: on track but heading where? *Higher Education* **63**, 237-256, doi:10.1007/s10734-011-9436-9 (2012).
- 6 Lorz, M., Schindler, S. & Walter, J. G. Gender inequalities in higher education: extent, development and mechanisms of gender differences in enrolment and field of study choice. *Irish Educational Studies* **30**, 179-198, doi:10.1080/03323315.2011.569139 (2011).

- 7 Li, W. Family background, financial constraints and higher education attendance in China. *Economics of Education Review* **26**, 724-734, doi:10.1016/j.econedurev.2007.09.001 (2007).
- 8 O'Connor, N. Hispanic Origin, Socio-Economic Status, and Community College Enrollment. *The Journal of Higher Education* **80**, 121-125 (2009).
- 9 Cameron, S. V. & Heckman, J. J. The Dynamics of Educational Attainment for Black, Hispanic, and White Males. *Journal of Political Economy* **109**, 455-499, doi:10.1086/321014 (2001).
- 10 Frempong, G., Ma, X. & Mensah, J. Access to postsecondary education: can schools compensate for socioeconomic disadvantage? *Higher Education* **63**, 19-32, doi:10.1007/s10734-011-9422-2 (2012).
- 11 Chan, W. K. & Ngok, K. Accumulating human capital while increasing educational inequality: a study on higher education policy in China. *Asia Pacific Journal of Education* **31**, 293-310, doi:10.1080/02188791.2011.594420 (2011).
- 12 McCowan, T. Expansion without equity: An analysis of current policy on access to higher education in Brazil. *Higher Education* **53**, 579-598, doi:10.1007/s10734-005-0097-4 (2007).
- 13 Ekinci, C. E. Impact of Some Socio-economic Factors on Higher Education Participation in Turkey. *Egitim Ve Bilim-Education and Science* **36**, 281-297 (2011).
- 14 Cardak, B. A. & Ryan, C. Participation in Higher Education in Australia: Equity and Access\*. *Economic Record* **85**, 433-448, doi:10.1111/j.1475-4932.2009.00570.x (2009).
- 15 Leslie, L. L. & Brinkman, P. T. Student Price Response in Higher Education: The Student Demand Studies. *The Journal of Higher Education* **58**, 181-204 (1987).
- 16 Heller, D. E. Student Price Response in Higher Education: An Update to Leslie and Brinkman. *The Journal of Higher Education* **68**, 624-659 (1997).
- 17 Neill, C. Tuition fees and the demand for university places. *Economics of Education Review* **28**, 561-570, doi:10.1016/j.econedurev.2009.01.002 (2009).
- 18 Paulsen, M. B. & St. John, E. P. Social Class and College Costs: Examining the Financial Nexus between College Choice and Persistence. *The Journal of Higher Education* **73**, 189-236 (2002).
- 19 Becker, G. S. Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy* **70**, 9-49 (1962).
- 20 Metcalfe, A. The geography of access and excellence: spatial diversity in higher education system design. *Higher Education* **58**, 205-220, doi:10.1007/s10734-008-9191-8 (2009).
- 21 Sá, C., Florax, R. J. G. M. & Rietveld, P. Determinants of the Regional Demand for Higher Education in The Netherlands: A Gravity Model Approach. *Regional Studies* **38**, 375-392, doi:10.1080/03434002000213905 (2004).
- 22 Mangan, J., Hughes, A., Davies, P. & Slack, K. in *Studies in Higher Education* Vol. 35 335-350 (2010).
- 23 James, R. Participation disadvantage in Australian higher education: An analysis of some effects of geographical location and socioeconomic status. *Higher Education* **42**, 455-472, doi:10.1023/a:1012264010667 (2001).
- 24 McCoy, S. & Byrne, D. 'The sooner the better I could get out of there': barriers to higher education access in Ireland. *Irish Educational Studies* **30**, 141-157, doi:10.1080/03323315.2011.569135 (2011).
- 25 Young, J. "Becoming different": Accessing university from a low socioeconomic community - Barriers and motivators. *Systemic Practice and Action Research* **17**, 425-469, doi:10.1007/s11213-004-5788-8 (2004).

- 26 Perna, L. W. & Titus, M. A. The Relationship Between Parental Involvement as Social  
Capital and College Enrollment: An Examination of Racial/Ethnic Group Differences.  
*Journal of Higher Education* **76**, 485-Oct (2005).
- 27 McDonough, P. M. *Choosing Colleges. How Social Class and Schools Structure Opportunity*.  
(State University of New York Press, State University Plaza, Albany, NY 12246 (paperback:  
ISBN-0-7914-3478-8, \$16.95; clothbound: ISBN-0-7914-3477-X). 1997).
- 28 Engberg, M. E. & Wolniak, G. C. Examining the Effects of High School Contexts on  
Postsecondary Enrollment. *Research in Higher Education* **51**, 132-153,  
doi:10.1007/s11162-009-9150-y (2010).
- 29 Perna, L. Vol. 21 *Higher Education: Handbook of Theory and Research* (ed John C. Smart)  
99-157 (Springer Netherlands, 2006).
- 30 Forrester, J. W. Industrial Dynamics - After the First Decade. *Management Science* **14**, 398-  
415 (1968).
- 31 Olaya, C. in *30th International Conference of the System Dynamics Society*.
- 32 Richmond, B. Systems thinking: Critical thinking skills for the 1990s and beyond. *System  
Dynamics Review* **9**, 113-133, doi:10.1002/sdr.4260090203 (1993).
- 33 McCarthy, N. Vol. 2 *Philosophy of Engineering and Technology* (eds Ibo van de Poel &  
David E. Goldberg) 265-273 (Springer Netherlands, 2010).
- 34 Poel, I. Vol. 2 *Philosophy of Engineering and Technology* (eds Ibo van de Poel & David E.  
Goldberg) 1-11 (Springer Netherlands, 2010).
- 35 Pitt, J. C. Vol. 3 *Philosophy of Engineering and Technology* 165-174 (Springer  
Netherlands, 2011).
- 36 Layton, E. T., Jr. Technology as Knowledge. *Technology and Culture* **15**, 31-41 (1974).
- 37 Bunge, M. in *Treatise on Basic Philosophy* Vol. 7 (Reidel Publishing Company, Dordrecht,  
Holland, 1985).