EDUCATIONAL SOFTWARE OVERCOMING BARRIERS FOR STUDENTS

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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The educational landscape of the world is plagued with inequality. There are three types of educational inequality, as described by a Cambridge professor named Goran Therborn: vital inequality; with respect to health and life expectancy, resource inequality; referring to economic comfort and opportunity, and existential inequality; which explains social and cultural factors that create inequality (Therborn, 2013). Certain inequalities have been better addressed than others over time. For example, the National School Lunch program was created to provide free and reduced lunch for students in 1946, and segregated schools based on race were made illegal in the United States in 1954. Changes like these can successfully address some forms of inequality. Yet unfortunately, inequality persists in many forms. Students who struggle to understand written English, who come from an uneducated family, or who read below grade level, are some examples of students who may not be well accommodated. Laura Czerniewicz, Director of the Centre for Innovation in Learning and Teaching at the University of Cape Town, claims that higher education institutions may not recognize how existential inequalities can become barriers to entry for students (Czerniewicz and Rother, 2018, p. 42). A school can focus on providing money and food and a school nurse, but it can be more difficult to recognize where it fails to meet the social or intellectual needs of its students. One researcher at the University of Hartford noted that "findings from nine studies revealed that English fluency seems to be a significant variable related to the adjustment of international college and university students" (Araujo, 2011, p.3). Even for students who are given the same resources and opportunity, it may be harder to succeed simply based on their own language, social experience, or cultural identity. As the presence of technologies in the lives of students continues to grow, research continues to discover the ways in which computation and data can attempt to reconcile some of these

longstanding shortcomings in public education. Research in the technical project will be centered on the use of learning analytics. Learning analytics, for the purposes of this report, means the leveraging of students' performance data to make predictions about their understanding of course material. The technical report will evaluate the degree to which a specific software system using learning analytics has a positive or negative impact on student success and retention. This STS paper will use social frameworks to discuss the relevant barriers and the ways in which educational technology can affect them. It will use two adaptations of the Social Construction of Technology, as initially described by Pinch and Bijker (1987). The whole project is tightly coupled because it focuses on the design and implementation of a technical system in higher education. The technical paper examines the implications of the models used, and the STS paper considers the design and accessibility of the software.

SOCIAL ANALYSIS OF HIGHER EDUCATION

In order to better understand the social impact of higher education, it is important to understand the roles it plays in the lives of different groups. This contextual understanding is further explored in Figure 1, which evaluates higher education as a technology for different stakeholders. The social pressure on higher education often comes from an outside force. For public schools, the government determines those regulations and requirements which define the overarching similarities across institutions. In addition, that outside force often determines funding for most of the individuals involved, as well as many projects sponsored by the institution. As a result, one of the key factors determining the design of higher education comes from a stakeholder which is not strictly involved in the use of the product. It should be noted that this is often the case with other technologies, like manufacturing and production. As a result, this oversight creates an interesting power dynamic due to the complex social relationships at play. In addition, from Figure 1 it can be seen that higher education must play a distinct role in the experiences of different groups. For example,

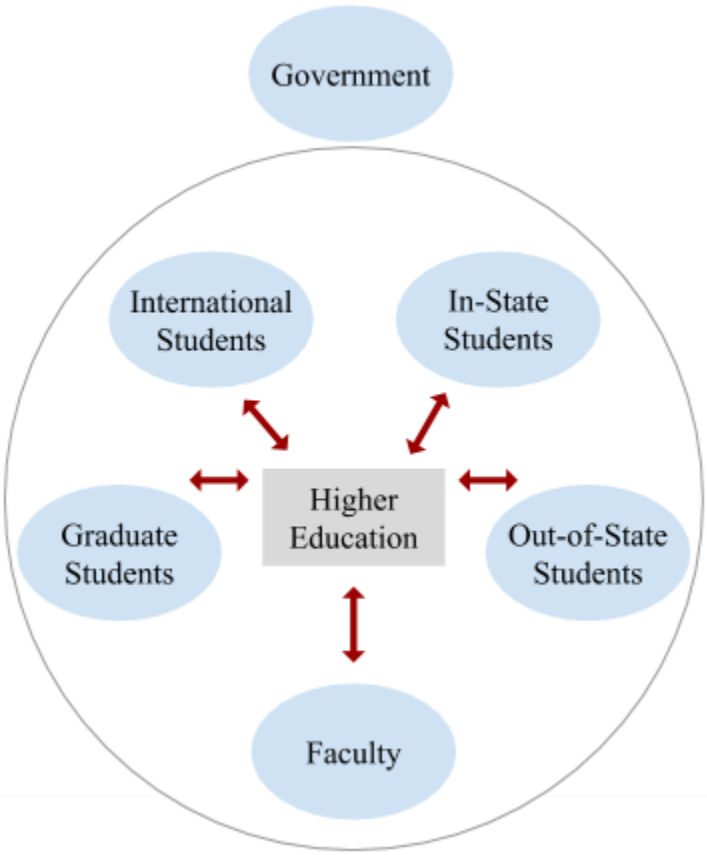

Figure 1: Social Construction of Higher Education: This figure shows some of the key social interactions between social groups and the technology of higher education. (adapted by Carrington Murphy (2020) from B. Carlson, 2009).

faculty need a higher education institution for their research and financial security and students expect to receive a good education. As a result, it becomes evident that those social groups actually help determine the purposes and goals of higher education. The determination of purposes and design by stakeholders is central to the idea of social construction of technology. However, it is also important to consider the ways in which higher education is actually equipped to deal with those differing needs and wants. In addition to being formed by those groups, it can also be described as having a high degree of interpretive flexibility. Interpretive flexibility means that higher education, as a technology, actually exhibits the characteristic of adapting to serve in a different role for different social groups (Pinch & Bijker, 1987). As a result, it becomes clear that the social dynamics create a product that is both multi-faceted and well-designed. This creates a conflict for the introduction of changes to the system like those proposed in the technical project. Moving to a new technology actually defines a novel interaction pattern for all social groups, and may upset the delicate balance on which higher education rests. These findings align with those by Ferguson et al. (2015) in their paper on the barriers to implementing learning analytics (p. 124).

Finally, it should be noted that the relationships between higher education and social groups can also be seen as an aggregation of the relationships between individuals. Individuals themselves define the desires of a social group, and may even differ substantially from the rest of their group. The intentional isolation of these relationships in education is greatly supported by the educational philosophy of differentiated learning. Basye (2018), education researcher and author of two books on learning techniques, describes differentiated learning as an educational philosophy that tailors the content of the curriculum and the methods of teaching to the individual student in order to maximize that student's success. Typically, differentiated learning

can also be associated with having both greater quality and greater quantity of interactions between the student and the teacher. Growing interest in educational technology has created an opportunity for teachers to tailor their curriculum and provide many ways of learning material which were not previously available. Educational videos are one simple example of a technology that lowers barriers for all kinds of students because they are able to choose a time and place which will allow them to continue to learn the material even though they may struggle in the classroom (Kay, 2012). While these types of opportunities are widely available, the question remains how effective they are.

SOCIAL ANALYSIS OF EDUCATIONAL SOFTWARE

Innovation and persistence define two ideals with which new technology systems are often approached. Both lofty and vague, these types of descriptions do not provide an adequate analysis of the social implications of implementing new technologies. The social relationships associated with educational environments can reveal key relationships and social factors which bring to light the most crucial implications of change. This discussion will focus on the introduction of a new educational software focused on learning analytics, which is evaluated further in the technical report.

In order to improve computer science courses at the University of Virginia, Professor Mark Floryan is building a piece of course software through which he hopes to encourage mastery of course material. In addition, the project aims to provide students with specific grading guidelines and live feedback. The hope is that by using this system students will have better understanding of what is expected of them and their current standing in the class. This understanding could support greater student confidence and retention of material.

The technical research report examines the ability of such a software system to accurately represent the learning process. In traditional class structures, an instructor will use student performance on quizzes, examinations, projects, and assignments to evaluate their knowledge of course material and assign a final grade. This project seeks to move this evaluation process into a computational model which predicts the probability that a student understands a given topic based on their performance in a series of opportunities to demonstrate competence. An effective system would allow students to progress through the class at their own speed while still encouraging mastery of all the course material.

The comments made in the following analysis provide a framework for evaluating the implementation of this technical project. In addition, however, the considerations discussed widely apply to the introduction of many new technologies in the classroom and can be used and adapted for a variety of other situations.

In order to further explain some of the key criteria for implementation, the social system in the classroom can be evaluated using a framework describing the technology and its role in social relationships. Figure 2 relates the relationships between individuals and the software system in addition to those among the individuals in the classroom. Based on this analysis, it becomes clear that there are many types of relationships present in the environment. The first element to

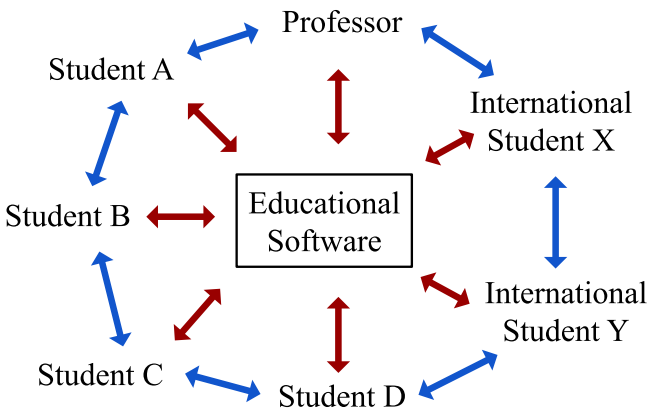

Figure 2: Technology and Social Relationships of an Educational Software System: This figure depicts the ways in which individuals interact with an educational software system with an additional focus on the relationships between individuals within the system. (adapted by Carrington Murphy (2020) from B. Carlson, 2009).

consider is those relationships among students and the professor, with the occasional inclusion of teaching assistants. While educational software can certainly strengthen or weaken the relationships in the classroom environment it is important to recognize that those relationships also act independently of the software. Any software or new technology added to this social framework must be free to adapt to a variety of different situations and different students. It cannot be too restrictive. The software should have an emphasis made on the ability of students and professors to grow, learn, and customize their experience. This might take the form of customizable layouts, new quiz formats, availability of lecture notes, among others. By promoting and allowing modification and adaptation, a software can better support the reality of the interaction patterns and relationships present within the classroom. At the same time, however, it is important to realize that these relationships will develop on their own. The relationships among individuals in the classroom are not actually represented by the software at all. While the software may be able to simulate those relationships, and provide a frame for their growth, they will, and should, grow without restriction.

From the analysis, it is also evident that there are a variety of relationships with technology which are integral to the design and development of the product. The arrows highlighted in red represent those relationships which should be the key focus of a user driven design. Following good software design principles, the designer should first observe and investigate the tasks that are going to be moved into this system. They should ask questions to understand the importance of certain routines, the relevance of certain details, and the failures of certain practices. In doing so, a list can be made which summarizes the use-cases which are most common for all possible stakeholders. Based on the many different types of relationships and

tasks performed, as well as the differing needs of individuals, it is clear that the software will have to be customizable and manage a variety of different users.

It is common, when implementing technology in the classroom, to come across common opposing ideas and rejections. The use of learning analytics is somewhat controversial because of often made assumptions which seem to place a lower value on the importance of the individual student. Perrotta and Williamson (2018), lecturers at the University of Leeds and the University of Stirling, respectively, critique the computational representation of a student as a "data double that can only ever be regarded as a temporary approximation stitched together from the available data points" (p.7). Perrotta's and Williamson's claims outline one of the key risks involved in using learning analytics: limited consideration of the many factors affecting learning. These concerns are especially valid for students who have accessibility needs which differ from the "average student." For those students, the learning process may not be able to be modeled in the same way. As one example, the classical model discussed in the technical report assumes that learning is a binary process and that it has a fixed probability of occurring each time a skill is performed (Corbett & Anderson, 1995). While these concerns are valid, they highlight a key point of emphasis for implementation. It should be clear that algorithms, data collection, and online resources are not intended to, nor are they able to, completely replace the complex social system present in the classroom. Though technologies may well reach that point, it is important to recognize and respect the current limitations. In order to make the most of learning analytics, all users should come to terms with the ways the technology is actually equipped to help them, and those ways in which it fails.

CONSIDERATIONS FOR IMPLEMENTATION

As a result of this analysis, it is clear that a specific emphasis must be made to account for all kinds of students which are part of the landscape. Some students have drastically different patterns of accessibility and methods of study. By evaluating students on an individual basis, students have the ability to vary the pacing of their own education. The complex learning process is one which takes different amounts of time and energy for different people. Data representations created can actually allow for greater freedom and flexibility since students are not evaluated simultaneously. In a standard grading system, instructors usually make a short-term approximation of student understanding based on some subset of all the information about a student's background and experience. Examinations are typically the same for all students, and usually are taken at the same time. Learning analytics allows for more specialization, where students are free to learn in the way that is best for them.

Accessibility functions are critical to consider when developing and implementing educational software. Specifically, it is important to provide resources which help to communicate the desired information in as many ways as possible, in order to meet all potential audiences. For example, a software system should be equipped with text-to-speech and language options to promote understanding.

While these types of resources are important, they do not necessarily provide equality across all possible barriers. The social barriers present in the classroom can be discouraged or enforced through an online software system. Software technology is one which has the power to provide access and content to all individuals regardless of their socioeconomic status, their image or culture, or their language or reading level. However, in order to retain this ability, the technology must be designed to equip all of these kinds of users to succeed. The implementers of

the technology should build an entire system, including both software solutions, and traditional ones, keeping this mission in mind.

Doing so will ultimately promote the success of more students. Sheila Smith (2005), a professor of business at Ball State University, claims “Instructional strategies that eliminate gender and racial bias, especially among African American women, are a crucial factor in the achievement of equity in information technology education and careers” (p. 22). The author concludes that “The issue of inclusion is a critical element in the information technology curriculum that will assist in the closure of the digital divide” (p. 22). Smith’s thoughts emphasize the results of this study, which suggest that the educational landscape will only benefit from the implementation of new technologies when they are practically designed and sufficiently evaluated for both accessibility and impact.

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