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Constructing a Complex Learning Community Index – Operationalizing the Concept of a Learning Community into a Measurable Construct

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Abstract

The fundamental challenge of higher education lies in its ability to intentionally design thriving, innovative, educational spaces that nurture and inspire transcendent and transformational outcomes at the individual, group, and institutional levels. One of the most studied high impact practices, a well-crafted learning community that fosters student-centered learning driven by collaboration, interdisciplinary study, and experiential learning is hypothesized to be one such educational space. This research advances the academic conversation regarding learning communities beyond nominal conceptualization and proposes an operational definition grounded on three dominant dimensions: (1) differentiation/diversity, (2) integration/association, and (3) feed-back/assessment loops. By constructing a "complex learning community" index, we translate the nominal conceptualization of the learning community into a measurable construct. By implementing a pre- and post-test of all incoming first-year students participating throughout our University's first-year learning communities over the course of two years, we offer insight as to learning community design and practices that influence transformational outputs, including flourishing and persistence.

Keywords

Complexity Theory, Flourishing

Introduction

Complexity theory hypothesizes that complex environments beget and nurture thriving and resilient environments. This research introduces and explores the relevancy of complexity theory with regard to designing transformational learning spaces. It also analyzes institutional data that is informative and instructive with respect to learning community design. Complex environments exhibit high degrees of differentiation, integrative action, feedback loops, and strategic adaptation (Johnson, 2007/2012, pp. 13-15). Having utilized a "complex learning-community index" designed to provide a composite measure of a given learning community's degree of "complexity" (as manifested by the above traits) and by implementing a pre- and post-test of all incoming first-year students participating throughout our University's first-year learning communities over the course of two years, we offer insight as to learning community design and practices that nurture or impede transformative learning experiences.

Specifically, we created a Complex Learning Community index (CLC Index) in which we attempt to measure the aggregate complexity of a given learning community by focusing on three dimensional characteristics: the degree to which the space is differentiated/diversified; the degree to which the space is associative or integrated; and the degree to which the space provides opportunities for adaptation through the presence of feedback loops. The CLC Index, which is derived by the aggregation of scores on each of the identified dimensions, allows the researcher to measure and analyze the general influence of the learning community in the aggregate, as well as the influences associated with each of the identified dimensions.

Through the lens of complexity theory and its application, we provide a fresh theoretical approach to the strategic design, implementation, and administration of learning communities. The paper demonstrates how theory informs practice. It is the goal of this research to inspire further conversation and insight with respect to designing learning communities that are cognitively rich and active, engage students with the value of diversity, promote integration and inclusion, and ultimately prepare students to be innovators, leaders, and problem-solvers in an increasingly complex global society.

Relevance of Complexity Theory

Complexity theory generalizes that complex systems energized by autonomous and responsible behavior yield surprising macro-level effects (Kiel, 2000, p. 67; see also Marshall, 2014, p. 25) that range from the idyllic to the catastrophic (Taleb, 2010, p. xvi). While cause, effect, and dependency are not often linearly predictive in complex, dynamic systems (Taleb, 2010, pp. 358-359), the emergence of evolving and adaptive macro-patterns is nonetheless regularly experienced and expected (Newell & Meek, 2000, p. 83; Taleb, 2010, p. xxvi, p. 358). Autonomous behavior is manifested through the acts of "independent micro-level agents" (Kiel, 2000, p. 67) in pursuit of independent micro-level interests. Autonomous behavior is "responsible" to the extent it conforms to system standards, norms, or expectations that promote and nurture advantageous emergent outcomes. It is "radical" to the extent that it obstructs the system's emergent properties. Given its potential for transformative and advantageous emergent outcomes, complexity is tolerated, revered, and even deliberately pursued. And yet, complexity also has the potential of producing catastrophic macro-level effects; consequently, complexity is also often feared, discouraged, and even opposed (Marshall, 2014, p. 25-26).

The recent and rising attention to complexity theory is triggering a paradigm shift with respect to exploring, critiquing, or designing social system constructs (Marshall, 2014, p. 26). It is "shifting attention from individual components and relationships to overall pattern[s] or motif[s] created by the system" (Newell & Meek, 2000, p. 83). This shift in focus is driven by an expectation that complex systems generally demonstrate long-run stability with respect to producing advantageous emergent patterns. It is this long-run stability that overshadows the system's associated risks. And the expected long-run advantageous patterns are attributed to be dynamically creative, evolutionary, entrepreneurial, and ultimately sustainable (Marshall, 2014, p. 26).

Accordingly, complexity theory offers insight to understanding how to create and maintain innovatively sustainable and progressive social systems:

> A good society, one that encourages individuals to realize their potential and permits complexity to evolve, is one that provides room for growth. Its task is not to build the best institutions, create the most compelling beliefs, for to do so would succumb to an illusion. Institutions and beliefs age rapidly; they serve our needs for a while, but soon begin to act as brakes on progress. . . . The task of a good society is not to enshrine the creative solutions of the past into permanent institutions; it is rather, to make it possible for creativity to keep asserting itself. (Csikszentmihalyi & Rathunde, 1993, p. 276, as cited in Kiel, 2000, p.72 and Marshall, 2014, p. 26-27)

In this regard, complexity theory offers strategic insights with respect to the challenges of higher education. A robust program of higher education encourages students to realize their potential within complex, dynamic learning spaces, and by doing so it provides room for transformational growth. The task of higher education is not only to provide students with the knowledge and skills necessary for to achieve success within their temporary-class-specific-spaces but also, and more importantly, to provide them with the knowledge and skills necessary to keep manifesting and asserting themselves in their post-graduate-life journeys.

The Foundational Components of a Complex-Spatial Learning Environment

It is generally accepted that a complex spatial environment is a spatial-system "in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution" (Mitchell, 2009, p. 13). More specifically, a complex-spatial environment is fueled by (a) a population of highly differentiated/diverse (individual) spatial-actors, (b) who are interactively engaged in integrative/associative behaviors that produce and use information revealed through their integrative actions, (c) such that all spatial-actors are in a persistent state of transformational learning via the environment's many feedback loops (Mitchell, 2009, p.12-13; Johnson, 2007/2012, p. 13-14).

The broad definition of *student success* proposed by Kuh, Kinzie, Schuh, and Whitt (2005) includes "satisfaction, persistence, and high levels of learning and personal development" (p. xiv). These are the dimensions that higher education hopes to deliver through its programmatic and curricular design. They are also found in a complex-adaptive spatial environment where spatial actors are persistently engaged in transformational and progressive evolutionary development.

Complex, Flourishing, and Thriving Spatial Environments

Complex spaces are also *flourishing* and *thriving* spaces. A *flourishing environment* is described as a space in which the spatial-actors have "an enthusiasm for life, are productively engaged with others and in society, and are resilient in the face of personal challenges" (Schreiner, 2010, p. 4; see also Keyes & Haidt, 2003). A *thriving environment* is described as one in which its spatial-actors are "not only academically successful, they also experience a sense of community and a level of psychological well-being that contributes to their persistence . . . and allows them to gain maximum benefit [from their relevant spatial environments]" (Schreiner, 2010, p. 4). Both of these constructs are aspirational constructs in the fields of education and positive psychology; they are essentially end-game properties of a complex-adaptive spatial environment.

Flourishing Environments

Actors in a *flourishing* environment are described as "productively engaged with others and in society" and "resilient in the face of personal challenges" (Schreiner, 2010, 4). To be productively engaged, actors often participate in integrative and associative initiatives and behaviors. Such behavior is a spatial mechanism through which information is processed, challenged, revealed, and even advanced. To be resilient, one must be able to absorb and adapt to spatial stress and shock (Dahlberg, 2015, p. 544). This resiliency also cultivates the essence of a flourishing and thriving space.

Resiliency generally refers to the "capacity of a material person, or biotype to survive sudden shocks" (Boin, Comfort, & Demchak, 2010, p. 36). In recent years, there has been an increased focus on what has been called "societal resilience," i.e., the ability for "organizations, cities, and societies [to] bounce back in the face of a disturbance" (Boin et al., 2010, p. 37). With respect to complex-adaptive spatial environments, resiliency means more than just being able to bounce back (Dahlberg, 2015, p. 544). The act of "absorbing shock" suggests that the space is processing all the information that is being channeled through the shock. And the act of "adapting to shock" suggests that the space itself is evolving and progressing. The ability of a complex system to adapt to stress and shock is what constitutes "its learning and transformational capabilities, not [merely] its ability to resist shock" (Dahlberg, 2015, p. 545; Meek & Marshall, 2016).

Relatedly, complex-spatial environments are highly adaptable and resilient because they typically involve a pool of actors who are highly differentiated in tastes, preferences, knowledge, backgrounds, and experiences and who have had the opportunity (and even motive) to engage in highly integrated and associative behavior. Through the (dis)integration of these many differentiated actors, feedback loops emerge, which ultimately leads to evolutionary and transformational progress and advancement. It is in this context that complex-spatial environments also beget flourishing outcomes. It is also in this context that complex-spatial environments are relevant to the task of designing flourishing learning communities.

Thriving Environments

Similarly, Schreiner (2010) describes a *thriving* environment as one comprised of "(1) engaged learning, (2) academic determination, (3) positive perspective, (4) diverse citizenship, and (5) social connectedness" (p. 4). As Schreiner explains, "engaged learning" and "academic determination" refer to the presence of both the effort and depth to which the spatial actors participate in and pursue learning opportunities within a given, defined academic space. In a thriving learning environment, spatial actors are "meaningfully processing the material, making connections between what they already know or are interested in and what needs to be learned. . . . They are energized by the learning process" (Schreiner, 2010, p. 4). "Diverse citizenship" refers to the presence of many differentiated/diverse actors who value their respective differences and "have an interest in relating to others from diverse backgrounds" (Schreiner, 2010, p. 4). And finally, "social connectedness" refers to the presence of connectedness and relationships, which ultimately nurtures a sense of community (p. 5). Through social connectedness integrative/associative behaviors are manifested and spatial actors discover, learn, progress, adapt, flourish, thrive, and experience resiliency. (See Table 1 for a comparison of complex adaptive, flourishing, and thriving environments.)

Table 1: Spatial Characteristics in a Complex Adaptive, Flourishing, and Thriving Environment.

Spatial Characteristics (Complex, Flourishing, and Thriving Spatial Environments)		
Complex-Adaptive Spatial Environments	**Flourishing Spatial Environments**	**Thriving Spatial Environments**
Populated with many differentiated/ diverse spatial actors.	Populated with spatial actors.	Populated with spatial actor who value differences in others.
Spatial actors are actively engaged integrated/ associative behavior through which information is produced, revealed and shared.	Spatial actors are "productively engaged" in integrative/ associative behavior "with other and society."	Spatial actors are engaged learners nurtured by the integrative and associative behavior of "making meaningful connections with other people."
The space is rich with learning opportunities via existing feedback loops.	Spatial actors are resilient in the face of personal challenges."	Spatial actors are "meaningfully processing the material, making connections between what they already know or are interested in and what needs to be learned… They are energized by the learning process."

While they are distinct spatial constructs (i.e. spatial-complexity, -flourishing, and -thriving), they are nonetheless related and relevant to each other. Complex-adaptive spatial environments experience long-run patterns of resiliency. This resiliency is cultivated by three essential spatial characteristics: (a) a population of many differentiated/diverse spatial actors, (b) who are actively engaged in integrative/associative behavior through which information is produced, revealed and shared, and (c) from which spatial actors are exposed to learning opportunities via existing feedback loops. While complex-adaptive-spatial environments are coveted for their property of resiliency, such complex-adaptive environments also beget flourishing and thriving outcomes. This is certainly expected, as well, since flourishing and thriving environments are observed to be the output of the same underlying attributes of a complex-adaptive spatial environment in which there is a presence of many differentiated/diverse actors, integration/associative behavior, and learning via feedback loops and assessment.

Complexity, The La Verne Experience, and FLEX Learning Communities

The University of La Verne strives to advance a holistic, values-driven, evidenced-based academic approach that seeks to craft and optimize the student's curricular and co-curricular educational experiences. This approach is branded "The La Verne Experience." Its mission is to provide students access to transformational learning opportunities and experiences through which they acquire transferable skills, competencies, and wisdom relevant to achieving life and community success (Weaver, Marshall, & Nelson, 2016).

The La Verne Experience is grounded on the hypothesis that transformational growth emerges when ideas connect in surprising new ways; when a familiar idea reveals something unexpected; or when a classroom concept becomes actively relevant to our respective life journeys, surrounding communities, and the broader world in which we connect. These "a-ha!" moments enlighten students and stir them to learn more. It is in these moments that deep and personal, transformative, and lasting learning occurs and that students learn how to construct new knowledge with which we are better able to address the complexities of a rapidly changing global world of connections and community (Weaver et al., 2016).

The La Verne Experience is designed to maximize student discovery and transformational growth by engaging the student in the academic art of connecting the self and ideas with others in and across classrooms, curricula, and communities. It is through our capacity to draw connections that students develop the skills and the confidence that leads to their academic success and beyond—success in civic and community life, as well as in their careers (Weaver et al., 2016).

The First-Year Learning Experience ("FLEX") is one of several signature programs of the La Verne Experience. Incoming, first-semester students are welcomed into one of approximately thirty-two (32) small, interdisciplinary learning communities, each consisting of three linked courses (typically two general education requirements and a writing course) that are separately taught yet collaboratively integrated. Programmatically, department chairs submit individual FLEX classes to their respective College Deans for inclusion in the program. These classes are then paired by the La Verne Experience office based on faculty requests. For example, the FLEX 7 learning community, "Markets and the Good Life," combines microeconomics, philosophy, and writing. FLEX 5, "The Interconnected World of Music and Psychology," is comprised of music, psychology, and writing. FLEX 9, "Atoms and Ecosystems," combines biology, chemistry, and writing. Through this first year learning experience La Verne students launch their collegiate academic experience in an integrated cross-disciplinary community of faculty and students intentionally designed to impact and optimize their first year educational experience. While 20% of FLEX learning communities are major specific, the majority are open to all majors, and FLEX selection is driven by student request. Additionally, and importantly, many of the FLEX learning communities also engage a community or civic partner or initiative and thereby further integrate the learning community's first-year experience to the realities of community and civic life. Finally, all faculty and students in the FLEX program participate in a common intellectual experience through the *One Book, One University* program, which provides another opportunity for engagement with our core values as well as opportunities for integration of assignments, ideas, and excursions (Weaver et al., 2016).

Operationalizing the Construct: "Complex Learning Community"

It is our hypothesis that a well-crafted learning community that incorporates complexity-friendly/informed high impact practices positively influences the resilient, flourishing, and thriving nature of the community and of the community's participants. To test this hypothesis, we constructed a CLC Index designed to aggregate the above discussed underlying complexity dimensions.

We operationalized each dimension separately by designing and distributing pre-and post-test survey instruments to all incoming first-year student's participating throughout La Verne's first-year learning communities. The survey instruments were designed to measure the presence and magnitude of spatial differentiation, integration, and feedback learning loops, all of which theoretically impact the complexity of the space (which impacts the educational aspiration of spatial flourishing and thriving).

The Proposed Model:

$Y = BX_1 + BX_2 + BX_3$

Where:

Y = Transformational Learning Space (characterized by its thriving, flourishing, and resilient nature).

Factors that influence *Transformational Learning Space* (explanatory variable):

X_1 = Spatial Differentiation/Diversity

X_2 = Spatial Integration/Associative Action

X_3 = Spatial Learning/Feedback Loops

The complexity of a given learning community is influenced by:

1. The extent to which the learning community experiences spatial differentiation/diversity with respect to both its spatial actors and subject matter;
2. The degree to which the learning community manifests associative and integrative behavior and practices, and provides opportunity for learning via feedback loops; and
3. The prospects of learning via a multiplicity of feedback loops.

Accordingly, our proposed CLC Index aggregates values on each of these dimensions. To measure these dimensional values, we designed and distributed pre- and post-test survey instruments to all students participating in La Verne's 2015 and 2016 FLEX programs. The survey instruments sought to measure a multiplicity of values indicating the degree of differentiation/diversity, integration/associative action, and learning/feedback loops within each of the learning communities (Figure 1). The unit of analysis is each individual learning community. Such measures provide information that can be used for comparing each learning community with respect to each of these dimensions, as well as ranking them in the aggregate with respect to their overall complexity. This data is relevant at the unit of analysis level because it provides a means for assessing the individual attributes of each learning community and testing whether the presence of each attribute influences student experiences. It is also relevant at the program level in terms of assessing the relevance and significance of high impact practices with respect to student learning and experience. It is also informative in terms of providing insight to FLEX faculty, leaders, and administrators as to the spatial dimensions of each FLEX learning community and whether such spatial dimensions impacted the over-all student experience.

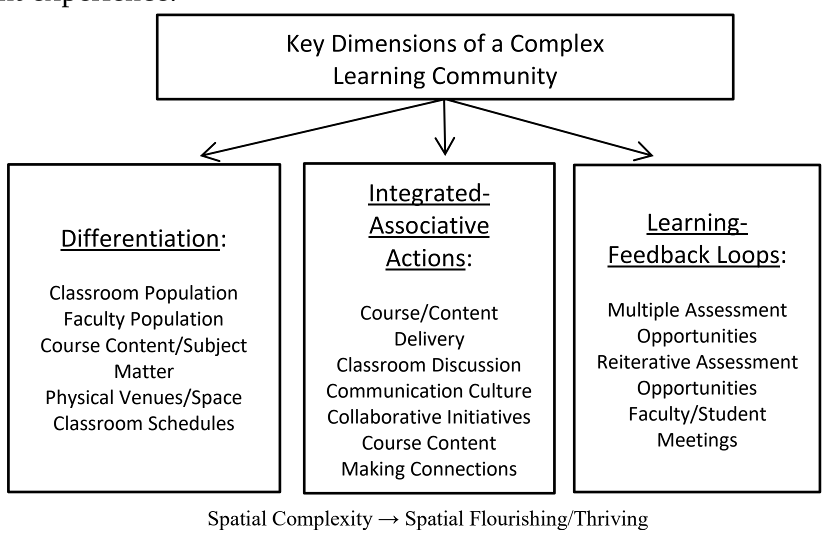

Figure 1: Key Dimensions of a complex learning community including differentiation, integrative-associative actions, and learning-feedback loops.

Within each dimensional component, the pre-and post-test survey instruments seek to measure a multiplicity of values theorized to have a potential influence with respect to each component (see Appendix). For example, while there are many obvious attributes that might differentiate spatial actors (e.g. gender, sexual orientation, race/ethnicity, major, commuter/residential, etc.), there are a number of other perhaps not so obvious attributes that influence the degree of differences among spatial actors (e.g., financial needs and experiences, employment, scholarship/financial aid awards and needs, academic interests, co-curricular interests). Similarly, our survey instruments incorporated a multiplicity of queries addressed to elicit values with respect to the presence of integrative/association and learn/feedback (see Appendix I).

Constructing a Complexity Index

Differentiation

Differentiation essentially looks at how much variation there is in terms of specific demographic variables applicable to actors within a space. Differentiation can be measured via many types of demographic information, including an actor's race/ethnicity, gender, socioeconomic status, religion, sexual orientation, marital status, place of origin, language, first generation status, etc. To measure differentiation for each type of demographic variable we used Simpson's Index of Diversity $[D = 1- \Sigma(n*(n-1))/(N*(N-1))]$ (Simpson, 1949). Simpson's Index of Diversity measures the total amount of diversity (or differentiation) in a space based on a specific demographic variable, with a maximum value of one and a minimum value of zero. A score of 0 indicates no differentiation in a space on a target demographic variable, while a score of 1 indicates complete differentiation. Thus, for the variable race/ethnicity, if there are five ethno-racial categories, White, Latino, Black, Asian, and Other, a score of 1 would indicate perfect differentiation (i.e., the same number of actors in each ethno-racial category) while a score of 0 would indicate no differentiation (i.e., all actors in a space share a single ethno-racial background).

If one wished to measure differentiation on four demographic variables—for instance, race/ethnicity, age, religion, and gender—the process would be the same. Using the formula above, an Index of Diversity score would be established for each demographic variable, race/ethnicity, age, etc., and then each score would be z-score standardized (z = (x-mean)/standard deviation). Since variables with more attributes have different ranges than those with only two or three attributes, this step ensures that no bias is introduced due to the number of categories in each variable. Once standardized measures are created for each variable, to calculate a total differentiation score for a space, the measures would be added together and divided by the total number of demographic variables used (four in this example). The result will be a standardized differentiation score for a space based on the chosen variables. It is important to use the same demographic categories for each space to ensure continuity and reduce bias.

In contrast to the integration variables, factor analysis was not used in conjunction with differentiation measures. This is because differentiation measures are not designed to measure a latent "differentiation" construct, but rather are designed as a type of index used to measure the amount of differentiation within the classroom environment. Each diversity measure on its own is a measure of whether a FLEX group is high or low in that particular type of differentiation (i.e., race, religion, socioeconomic status, etc.). When added together and then standardized, the differentiation index gives an indication of how much total differentiation is present within each FLEX in comparison to other FLEXs at the university. Factor analysis would not work for such a construct, as it is to be expected that each variable that makes up this differentiation index measures very different types of latent constructs.

Integration

Integration variables measure the level of connectedness within a space, including measures of collaboration between actors, culture of openness, sense of community, and other measures of social connectedness. To create an integration measure, we z-score standardized each integration variable and then added all scores together and divided by the total number of integration variables. Integration was split into two separate types of integration: social capital-based integration and linked-based integration. Social capital integration refers to integration *within* the classroom in terms of cohesion and connection between students. Eight social capital variables were included: every voice mattered; the cultural environment was collaborative; the environment was culturally inclusive; discussions were robust; the discussion environment was safe; students worked in groups; there was a sense of community; and new friends were made. Linked integration indicates the integration that occurred *among* the three classes that were part of the FLEX experience, including the following variables: discussions were linked between courses, course content was connected, courses were connected, and courses were integrated (see Appendix 1 for more definitional details regarding variables).

Factor analysis is used to ensure integration variables are measuring similar latent constructs. Factor analysis for the social capital integration variables indicates that only one latent variable is present with respect to the eight variables used to measure social capital integration (Table 2a: Factor 1 Eigenvalue = 4.46; Factor 2 Eigenvalue = 0.43; Factor 3 Eigenvalue = 0.18). Typically eigenvalues over 1.0 are considered relevant latent variables. An analysis of Cronbach’s Alpha further supports the consistency of the latent construct of social capital integration (Cronbach’s Alpha = 0.91). Typically a Cronbach Alpha measure over 0.70 indicates high internal consistency and reliability for a measure.

A similar analysis was also conducted for the latent construct of linked integration. Factor analysis indicated that only one latent variable was present with respect to the four variables used to measure this construct (Table 2b: Factor 1 Eigenvalue = 2.97; Factor 2 Eigenvalue = 0.07). An analysis of Cronbach’s Alpha further supports the consistency of the latent construct of the linked integration measure (Cronbach's Alpha = 0.92).

Because the two integration variables have a fairly high correlation of 0.62, we use the Variance Inflation Factor procedure to test if multicollinearity was a possible issue in our models. For each of the four models, the highest VIF was 1.91, with an average that ranged from 1.45 to 1.51. Variables in models that have VIFs over 10 are candidates for multicollinearity. Thus, we were able to rule out multicollinearity being an issue in any of our regression models that used our two integration variables (i.e., social capital and linked).

Table 2a. Eigenvalue and Cronbach's Alpha for Social Capital Integration.

Variable	Factor 1	Factor 2	Factor 3
Every voice mattered	0.75	0.08	0.21
Collaborative cultural env.	0.87	-0.01	-0.10
Env. of cultural inclusivity	0.86	0.09	-0.20
Robust discussions	0.71	0.17	-0.17
Safe discussion env.	0.68	0.26	0.05
Group work	0.60	0.16	0.23
Sense of community	0.80	-0.27	0.05
Made new friends	0.66	-0.46	0.02

Cronbach's Alpha = 0.91

	Eigenvalue	*Difference*	*Proportion*
Factor 1	*4.46*	*4.03*	*0.95*
Factor 2	*0.43*	*0.25*	*0.09*
Factor 3	*0.18*	*0.09*	*0.04*

Table 2b. Eigenvalue and Cronbach's Alpha for Linked Integration.

Variable	Factor 1	Factor 2
Discussion linked between courses	0.76	0.18
Course content connected	0.97	-0.01
Cources Connected	0.89	0.05
Courses Integrated	0.81	-0.20

Cronbach's Alpha = 0.92

	Eigenvalue	*Difference*	*Proportion*
Factor 1	*2.97*	*2.90*	*1.02*
Factor 2	*0.08*	*0.11*	*0.03*

Feedback Loops

Feedback loop variables measure the extent to which actors in a space are provided with meaningful feedback that could be used to assess their performance and make improvements when necessary. Variables that can be used to measure feedback included types assessments of work completed, frequency of assessment, time spent evaluating assessments, or time spent mentoring. To create a feedback loop measure, we z-score standardized each feedback variable, added all scores together, and divided by the total number of integration variables.

Application of Complexity Index: The Methodology

Data were collected at two points in time, during the fall semester of 2015 and the fall semester of 2016. A survey was administered twice during each fall semester, once at the beginning of the semester (Phase 1) and once at the end (Phase 2). For fall 2015, in Phase 1, 526 respondents completed the survey (response rate = 73%), while during Phase 2, 286 students completed the survey (response rate = 40%). The lower response rate in Phase 2 was due to the implementation of a different method of acquiring data—in person pen and paper (Phase 1) versus electronic surveys respondents completed online (Phase 2). For fall 2016, in Phase 1, 513 respondents completed the survey (response rate = 92%) while during Phase 2, 437 students completed the survey (response rate = 79%). In subsequent studies, we strongly recommend a pencil and paper method (as was done in fall 2016) since this is more likely to result in a high response rate. Surveys questions—74 in Phase 1 and 95 in Phase 2—were designed to gather demographic information as well as tease out student perceptions regarding spatial differentiation, integration, and learning/feedback loops.

Dependent Variables

The study identified and included three dependent variables: student flourishing, retention, and the respondent's overall evaluation of their first semester FLEX experience.

Student Flourishing

The flourishing scale measures "flourishing" using the Diener et al. (2009) flourishing scale. The flourishing scale uses eight questions scored on a seven point Likert scale ranging from (1) strongly disagree to (7) strongly agree. Scores on these questions are aggregated to create a flourishing scale outcome (min = 8, max = 56) (Likert, 1932). The eight questions for the scale are the following:

1. I lead a purposeful and meaningful life.
2. My social relationships are supportive and rewarding.
3. I am engaged and interested in my daily activities.
4. I actively contribute to the happiness and well-being of others.
5. I am competent and capable in the activities that are important to me.
6. I am a good person and live a good life.
7. I am optimistic about my future
8. People respect me.

A high score on the flourishing scale (max = 56) indicates a respondent with many psychological resources and strengths.

Retention/Persistence (fall 2015-spring 2016 and fall 2016-spring 2017)

Retention/persistence rates indicate the percentage of students in a FLEX classroom that continued on as students during the semester following their FLEX semester (first semester of their first-year). For 2015-16, the retention variable ranged from a low of 71% to a high of 100%, with a mean of 95.7%. A majority of FLEXs, 27 out of 33, had retention rates above 90%. For 2016-17, the retention variable ranged from a low of 78% to a high of 100%, with a mean of 90.9%. A majority of FLEXs, 18 out of 27, had retention rates above 90%.

We also examined year-over-year retention from fall to fall and found that for both 2015-16 and 2016-17 there was no significant relationship between fall-to-fall retention and our integration measures. We believe this is because fall-to-fall retention rates reflect more attrition based on financial factors (i.e., inability to pay tuition) than fall-to-spring retention rates. Thus, without an effective measure of financial challenges to be used as a control, the fall-to-spring retention rates are more likely to show variation due to the FLEX learning community experience than are fall-to-fall retention rates.

First Semester FLEX Experience

The FLEX experience variable measures respondents' rating of their overall experience in their FLEX classroom. This variable was measured using responses to the following question: "I would recommend my FLEX learning community to future first-years." The possible responses were strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). Responses were then z-score standardized so they could be compared to other standardized outcome measures.

Results

Of the total FLEXs studied in the two-year period, there were 48 (fall 2015 = 25; fall 2016 = 23) that maintained the minimal sample size for each phase to remain in the study (minimum n = 5). From this sample, we were able to derive a complexity index for each of the FLEX-learning communities, as well as derive a separate sub-index for each of the identified dimensions (spatial differentiation/diversity, spatial integration, and spatial/learning and feedback loops). Using these measures, we were able to assess the entire FLEX program, as well as each of the individual FLEX-learning communities with respect to overall spatial complexity, as well as two of the subcomponents, differentiation/diversity and integration. Our results indicated that the learning/feedback dimension was closely correlated with our integration measure, and therefore, we excluded it from the results. Moreover and importantly, we were also able to test whether spatial complexity or any of its dimensions influenced student experience, flourishing, and retention.

Tables 3a and 3b below show values for each FLEX-learning community relating to the key dependent variables of this sample analysis (first semester FLEX experience, flourishing, and retention rates) as well as the key complexity variables (differentiation, social capital integration, and linked integration). With the exception of the flourishing scale and retention rate, the remaining values were converted and scaled to equivalent standardized z-scores ranging from –3.9 to 3.9. For example, Table 3a indicates that in FLEX 8, 16 students responded to the Phase 1 survey and 11 to the Phase 2 survey. FLEX 8 also scored high in flourishing (i.e. scoring 54.35) and in overall first-semester experience (i.e. scoring 1.36) and also retained 100% of the cohort. While it scored low in spatial differentiation (i.e. scoring –0.25), it scored among the highest in measures for both social capital (i.e. scoring 1.77) and linked integration (i.e. scoring 1.36). Sorting results this way demonstrates the strong association between the FLEX Experience outcome and the integration variables (Tables 3a and 3b). From the perspective of program and administrative review, this information is relevant for understanding the general spatial characteristics of the entire program, as well as understanding each individual FLEX. For example, how did FLEX 8 score with respect to overall experience and flourishing? Why did FLEX 34 score so low? Programmatic awareness is important in terms of implementing strategic programmatic review, admissions/registration decisions, assessment, and adjustments.

Table 3a. FLEX Classrooms by Key Dependent and Independent Variables (Fall 2015).

FLEX	n1	n2	Flourishing	Retention	FLEX Exp	Differen.	Int_Soccap	Int_Linked
2	10	6	41.50	0.71	0.34	-0.81	-0.67	-0.74
3	17	10	46.85	1.00	0.06	-0.64	-0.29	-0.06
4	11	6	49.00	1.00	0.60	-1.26	1.20	0.83
5	12	6	43.00	1.00	0.06	-0.82	-0.22	0.01
6	17	11	44.68	1.00	0.55	0.13	-0.14	1.26
7	24	13	45.96	0.92	0.81	0.86	0.83	1.17
8	16	11	54.35	1.00	1.36	-0.25	1.77	1.36
9	28	21	43.63	0.95	-0.02	-0.50	-0.48	0.01
10	38	16	48.40	0.80	0.06	0.89	-0.01	0.78
11	21	13	45.75	0.92	-0.55	0.12	0.35	1.59
12	28	13	46.25	1.00	0.19	-0.16	0.17	0.53
13	24	13	49.65	1.00	0.57	2.17	0.49	-0.12
14	18	15	48.40	1.00	1.25	0.09	1.02	0.72
16	14	7	46.79	1.00	0.06	-0.26	0.30	1.21
19	15	12	46.25	1.00	0.19	1.46	0.38	-0.25
21	11	7	47.25	0.71	-1.28	1.04	-1.21	1.11
22	11	7	50.90	0.86	-0.26	1.29	-1.19	-1.21
24	14	12	49.13	1.00	0.34	0.78	0.02	0.20
25	11	7	46.36	1.00	-0.16	-1.95	0.10	-2.03
26	8	8	43.25	1.00	-0.13	-1.22	-0.94	-1.00
27	18	7	46.79	1.00	0.06	0.79	-1.25	-0.58
28	19	18	46.12	1.00	-0.33	1.19	-1.02	-1.46
29	18	6	45.50	1.00	0.60	0.95	0.68	0.60
34	8	5	44.30	0.83	-3.50	-0.76	-2.62	-2.52
35	7	8	48.88	0.89	-0.34	-0.21	0.55	-0.24

Table 3b. FLEX Classrooms by Key Dependent and Independent Variables (Fall 2016).

FLEX	n1	n2	Flourishing	Retention	FLEX Exp	Differen.	Int_Soccap	Int_Linked
1	20	18	47.17	0.92	0.01	0.81	1.24	1.23
2	15	15	49.07	0.93	0.27	-1.03	-1.28	-1.26
4	10	10	49.10	1.00	0.09	-0.28	-0.78	-0.93
6	21	20	49.90	1.00	0.88	1.82	0.99	0.67
7	28	29	52.21	0.93	1.11	-0.35	1.81	1.78
8	13	11	51.91	0.92	1.01	0.11	1.10	1.56
9	36	34	48.81	0.91	-0.04	-0.08	-0.95	-1.05
10	33	26	49.73	0.88	0.48	0.47	0.52	0.26
11	17	12	49.83	0.93	0.88	2.95	0.59	0.37
12	33	23	51.96	0.95	0.59	0.46	0.81	1.02
13	34	31	47.42	0.83	0.33	0.08	-0.49	-0.75
14	21	19	49.84	0.82	-1.59	-0.22	-0.90	-1.09
16	19	19	49.38	0.89	0.80	-0.59	0.72	0.37
18	17	17	47.53	1.00	-0.59	-1.26	-1.16	-1.11
19	16	14	50.43	0.83	-1.74	1.15	-0.47	0.04
20	14	17	48.25	0.81	-0.75	-0.81	-0.80	-0.78
21	15	17	49.65	0.97	0.80	-0.31	-0.15	-0.65
22	18	18	48.94	0.94	0.30	0.47	-0.50	-0.69
24	22	20	48.89	0.98	1.27	-0.99	0.84	0.86
26	14	13	50.46	0.93	-0.04	-1.31	0.03	0.51
27	19	17	51.88	0.94	-1.35	-1.17	-1.31	-1.03
28	17	9	49.33	0.92	-0.15	-1.12	-0.31	-0.12
29	10	9	49.75	0.79	-2.77	0.57	-1.57	-1.10

Hypothesis Testing: Complex Learning Spaces

As stated above, the data generated through the use of our CLC Indices is also relevant and of value with respect to testing the hypothesis that spatial complexity, differentiation, integration, and learning/feedback loops influence student experiences (Figure 2).

CLC Index Hypotheses:

H_1: Spatial Learning Community Complexity → Student Experience/Flourishing/Retention

H_2: Spatial Differentiation/Diversity → Student Experience/Flourishing/Retention

H_3: Spatial Integration/Association → Student Experience/Flourishing/Retention

H_4: Spatial Learning/Feedback Loops → Student Experience/Flourishing/Retention

Figure 2: CLC index hypotheses.

Hypothesis Testing: Flourishing

The results of regressing complexity measures of differentiation and integration on the level of respondent flourishing within each FLEX indicated that there was a strong relationship between social capital integration and flourishing (b = 1.30, p = .003). Thus, for a one standard deviation increase in the level of social capital type integration within a FLEX, there was a corresponding 1.30 increase in flourishing within the FLEX (Table 4). See Figure 3 for a visual representation of this relationship. However, there was no significant relationship between FLEX differentiation and flourishing (b = 0.48, p = .115), nor was there one between FLEX linking and flourishing (b = –0.51, p = .192). The significant year dummy variable (base year = 2015) indicated that 2016 FLEX groups had higher flourishing scores than did 2015 FLEX groups. The regression included 48 FLEXs and had an R-squared value of 0.47.

Table 4. Flourishing by Complexity Components.

	Flourishing Scale			
	beta	S.E.	p-value	
Complexity:				
Differentiation	0.48	0.299	0.115	
Integration (social capital)	1.30	0.411	0.003	**
Integration (linked coures)	-0.51	0.386	0.192	
Year (dummy, base = 2015)	2.87	0.578	0.000	**
Constant	46.84	0.402	0.000	**
n			48	
R^2			0.47	

All FLEX groups with a response rate less than 5 respondents were dropped from the model.
Flourishing scores ranged from 40 to 55.
All Diversity and Integration scores were standardized (-3 to +3 range).
VIFs in this model ranged from 1.01 to 1.90, with an average VIF of 1.45.
*** $p \leq 0.01$, * $p \leq 0.05$, † $p \leq 0.10$*

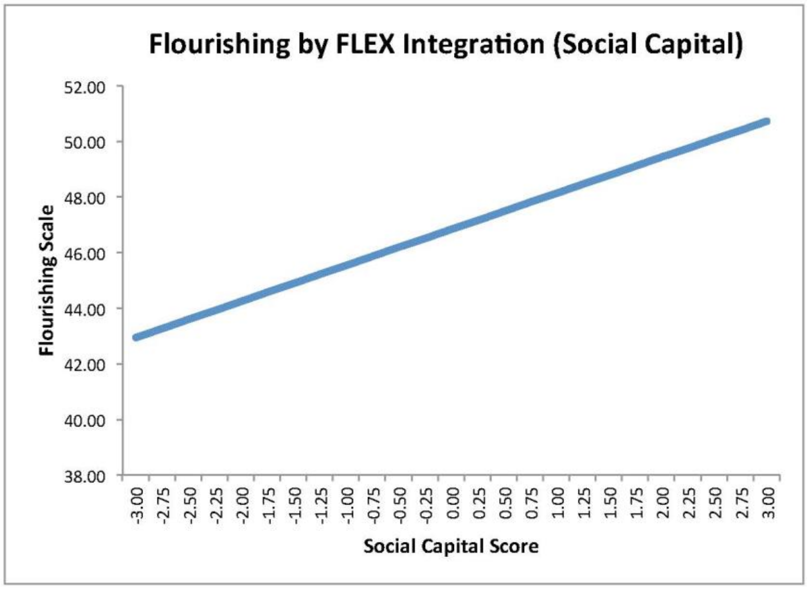

Figure 3. Graph of flourishing in relation to FLEX integration (social capital).

Because the results of Table 4 indicated that both differentiation and social capital integration were both close to significance, we decided to examine the tenant of complexity theory that suggests that, when combined with high levels of integration, high levels differentiation will lead to creativity/innovation and other positive outcomes. When adding an interaction term for differential times each type of integration, we found significant positive main effects for social capital integration ($b = 1.22$, $p = .004$) and to a lesser degree differentiation ($b = 0.52$, $p = .080$) (Table 5). However, inimical to complexity theory predictions, the results indicated a significant but negative association for the interaction between differentiation and social capital integration ($b = -0.95$, $p = .043$). Non-significant results were shown for the main effect of linked integration ($b = -0.57$, $p = .129$) as well as the interaction between differentiation and linked integration ($b = 0.02$, $p = .944$). The significant year dummy variable (base year = 2015) indicated that 2016 FLEX groups had higher flourishing scores than did 2015 FLEX groups. The regression included 48 FLEXs and had an R-squared value of 0.55. These interaction results suggest a significant negative interaction between differentiation and social capital integration, indicating that FLEXs that are high in differentiation will have declining flourishing scores as their level of social capital integration increases. This is not a completely unexpected result as one sees similar results when looking at neighborhood studies that show how difficult it is to achieve high levels of social capital when there are also high levels of differentiation (Putnam, 2007). We speculate that creating complexity is hard and that there is a fine line between creating a flourishing complex space and one that is failing when levels of differentiation are high.

Table 5. Flourishing by Complexity Components with Component Interactions.

	Flourishing Scale			
	beta	S.E.	p-value	
Complexity:				
Differentiation	0.52	0.291	0.080	†
Integration (social capital)	1.22	0.393	0.004	**
Integration (linked coures)	-0.57	0.369	0.129	
Diff X Integ_soccap	-0.95	0.455	0.043	*
Diff X Integ_linked	0.02	0.323	0.944	
Year (dummy, base = 2015)	3.12	0.561	0.000	**
Constant	46.82	0.391	0.000	**
n			48	
R^2			0.55	

All FLEX groups with a response rate less than 5 respondents were dropped from the model.
Flourishing scores ranged from 40 to 55.
All Diversity and Integration scores were standardized (-3 to +3 range).
VIFs in this model ranged from 1.05 to 1.91, with an average VIF of 1.51.
*** $p \leq 0.01$, * $p \leq 0.05$, † $p \leq 0.10$*

Hypothesis Testing: Student Retention

Results of regressing complexity measures of differentiation and integration on retention rates for each FLEX indicated that there was a significant relationship between social capital integration and retention (b = 0.032, p = .049). Thus, for a one standard deviation increase in the level of social capital integration within a FLEX class, there was a corresponding 3.2% increase in retention rates for that FLEX (Table 6). See Figure 4 for a visual representation of this relationship. Conversely, there was no relationship between differentiation (b = –0.01, p = .417) or linked integration (b = 0.00, p = .834) and retention. The year dummy variable (base year = 2015) also was not significant, indicating that both years had similar retention rates when controlling for other variables in the model. The regression included 48 FLEXs and had an R-squared value of 0.16. Note that a model that included an interaction between differentiation and integration was run, but the interaction was not significant.

Table 6. Retention by Complexity Components.

	Retention		
	b	SE	p-value
Complexity:			
Differentiation	-0.01	0.011	0.417
Integration (social capital)	0.03	0.016	0.049 *
Integration (linked coures)	0.00	0.015	0.834
Year (dummy, base = 2015)	-0.03	0.022	0.166
Constant	0.95	0.015	0.000 **
n			48
R^2			0.16

All FLEX groups with a response rate less than 5 respondents were dropped from the model.
Retention ranged from 71 to 100% for FLEX groups.
All Diversity and Integration scores were standardized (-3 to +3 range).
VIFs in this model ranged from 1.01 to 1.90, with an average VIF of 1.45.
*** $p \leq 0.01$, * $p \leq 0.05$, † $p \leq 0.10$*

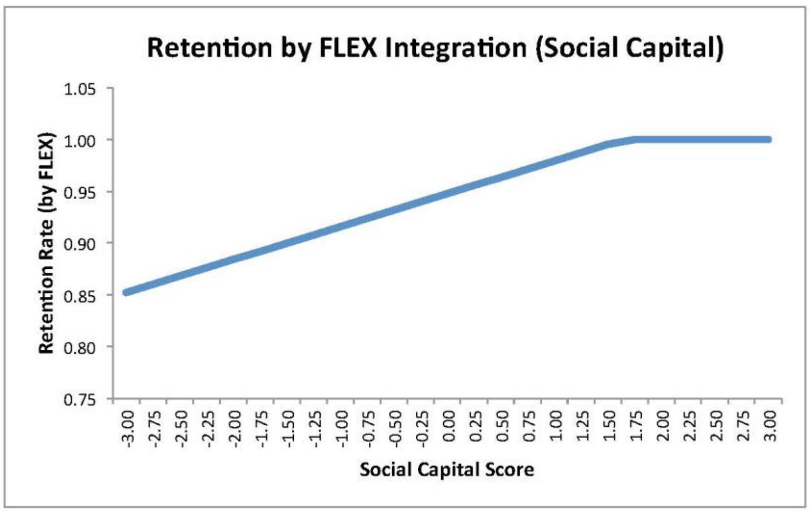

Figure 4. Graph of retention in relation to FLEX integration (social capital).
Note: Trend line has been artificially truncated at 1.0 to reflex true retention rate outcomes.

Hypothesis Testing: First Semester FLEX Experience

We also extended our test of the complexity model to a simple variable that measured a student’s experience within the FLEX class. When regressing the differentiation and integration components of complexity on respondent’s FLEX experience, we found that both forms of integration—social capital (b = 0.44, p = .003)) and linked (b = .038, p = .006)—were statistically significant. Thus, for a one standard deviation increase in either social capital or linked integration, there was slightly less than half a standard deviation increase in FLEX experience (Table 7). However, the results indicated no significant relationship between differentiation and the FLEX experience (b = –0.06, p = .556), nor the time dummy variable (b = 0.01, p = .973). The regression included 48 FLEXs and had an R-squared value of 0.55. A model that included an interaction between differentiation and integration was run, but the interaction was not significant.

Table 7. FLEX Experience by Complexity Components.

	FLEX Experience			
	b	SE	p-value	
Complexity:				
Differentiation	-0.06	0.101	0.556	
Integration (social capital)	0.44	0.139	0.003	**
Integration (linked coures)	0.38	0.131	0.006	**
Year (dummy, base = 2015)	0.01	0.196	0.973	
Constant	0.05	0.136	0.721	
n			48	
R^2			0.55	

All FLEX groups with a response rate less than 5 respondents were dropped from the model.
FLEX Experience scores were standardized (-3 to +3 range).
All Diversity and Integration scores were standardized (-3 to +3 range).
VIFs in this model ranged from 1.01 to 1.90, with an average VIF of 1.45.
*** $p \leq 0.01$, * $p \leq 0.05$, † $p \leq 0.10$*

Hypothesis Testing: Community Engagement and Integration

Because social capital integration consistently had statistically significant positive relationships with our outcome variables (i.e., flourishing, retention, FLEX experience), we decided to examine three of the high impact practices related to community engagement that have been implemented in conjunction with the FLEX program to see if there was a relationship between these practices and social capital integration (Table 8). All students in the FLEX program had the opportunity to partake in a community engagement day with the FLEX at the beginning of the fall semester, although not all students participated. Depending on the FLEX instructors, other students also had the opportunity to participate in a class field trip and/or a community engagement project in which the class worked with a community member on a project during the entire fall semester. Regression results indicate that both the class field trip and the community engagement project have substantial positive relationships with social capital integration. Conversely, participation in the one-day community engagement activity was not significantly related to an increase in social capital integration. These findings suggest that both field trips and long term community-engaged projects are associated with increases in integration social capital, which in turn is related to increased student flourishing, retention rates, and students’ perceived FLEX experience.

Table 8. High Impact Practices Associated with Integration (Social Capital).

	Integration (Social Capital)			
	b	beta	S.E.	p-value
High Impact Practices (participation):				
Class Field Trip	1.32	0.39	0.483	0.009 **
Community Engagement Day	0.27	0.08	0.669	0.684
Community Engagement Project	0.68	0.36	0.299	0.029 *
Year (dummy, base = 2015)	-0.54	-0.29	0.423	0.208
Constant	-1.48		0.717	0.045 *
n				48
R^2				0.25

All FLEX groups with a response rate less than 5 respondents were dropped from the model.
FLEX Integration scores were standardized (-3 to +3 range).
Community Engagement Day and Field Trip variables indicate the percentage of students from a FLEX group that participated in each event.
Community Engagement Project was a dummy variable indicating if a FLEX group did or did not participate in a community engagement project throughout the semester.
Note: beta coefficients have been standardized to allow comparison between variables.
*** $p \leq 0.01$, * $p \leq 0.05$, † $p \leq 0.10$*

Conclusion

By reframing the examination of high impact practices within the lens of complexity theory, we are better able to operationalize the construct of "a well-crafted learning community." Such measurement is approximated through the development, construction, and implementation of a Complex Learning Community Index derived from three foundational dimensions: spatial differentiation, spatial integration, and spatial learning-feedback loops. These measures are informative at both the macro-programmatic level and the micro-learning community level. At the macro-level, we can now rank order each FLEX community according to spatial complexity in the aggregate, as well as according to each of the identified foundational dimensions. At the micro-level, we can use this information to inspire conversation and strategic design with respect to specific learning community design and delivery.

Importantly, the construction and utilization of the CLC Index also allows us to begin testing important foundational hypotheses regarding the design and use of learning communities as a high impact practice with regard to educational delivery strategies. The data, which spans two semesters, indicates that the degree of spatial complexity is significantly relevant and influential in the design and delivery of a learning community. It is important to note that integrative and associative behavior within any given FLEX learning community appeared to have the strongest relationship with outcomes such as student experience, flourishing, and retention. At this stage of our research, it appears that integrative and associative behavior is one of the most important attributes of a flourishing and thriving learning community. Such data-driven awareness provides support and strategic insight (at both the administrative and faculty levels) that the creation of integrative learning community environments is worthy of the time and resources necessary to do so. This includes creating learning communities that foster frequent and engaged discussion, an open and safe environment, cultural collaboration and inclusion, and a strong sense of community.

Our analysis and findings, however, have their limitations. First, our study is grounded on only two semesters of data extracted from a pre-and post-test survey delivered to students in the fall 2015 and 2016 FLEX programs. While these results suggest promising outcomes for well-integrated learning communities, more data is necessary to conclusively support such findings. Second, the post-test survey (Phase 2) for fall 2015 had a relatively small response rate (N= 286)—less that 50% of the overall FLEX population. Third, the survey-instruments are self-reported, and use of the data assumes that respondents understood the fundamental meaning of the survey terms and questions. We were surprised that the differentiation/diversity dimension did not have a larger, significant impact on student experience. We were also surprised that the learning/feedback dimension was so correlated with our integration measure. More work is needed to find unique measures of learning/feedback. Accordingly, at this time, we cannot reject the null hypothesis that learning/feedback dimensions have zero impact on student experience, flourishing, and retention.

Finally, we also note that use of the CLC index was not used as part of faculty evaluation nor promotion and tenure. Data from the CLC index was confidential and was thus presented in aggregate to upper administration and colleges/departments to encourage support for integration and the program. We did share individual FLEX data with participating faculty each year for their personal information and use in improvement.

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Appendix
Complexity Dimensions

Differentiation Parameters:
Socio-demographic-cultural characteristics of spatial actors (student/faculty):

- Geo-cultural origins?
- Gender/ Race/ Ethnicity/ Sexual Orientation?
- Sexual Orientation?
- Marital Status
- Parented Child(ren)?
- Siblings?
- Religion/ Faith-Based?
- First Generation?
- Household Educational Experiences?
- Financial?
  - Scholarship Recipient?
  - Student Loan Debt?
  - Employment Status (No. hrs/week)?
  - Employment Required?
  - Family Tuition Assistance?
- Commuter (no. of miles)?
- Academic Interests?
  - Major (un)determined?
  - Subject Matter?
- Co-Curricular Interests and Participation

Integration/ Associative Action [Post-test]:
Integration – Social Capital

- FLEX nurtured sense of community
- Collaborative Culture Experience
- Inclusive Culture Experience
- FLEX engaged in open and robust discussions
- FLEX nurtured an open and safe environment for discussion
- Every voice mattered
- FLEX community worked in productive groups
- I made new friends among my classmates in my FLEX

Integration – Linked FLEX Courses

- FLEX Faculty connected course content
- Faculty Collaboratively Integrated Content
- FLEX community discussed linkage of course content
- FLEX professors illustrated and made connections of the linked course content

Learning/ Feedback Loop Parameters:
Assessment Feedbacks:

- FLEX faculty used multiple methods for assessing performance?
- FLEX faculty used several different teaching methods conducive to student learning styles?
- FLEX faculty provided frequent and meaningful feedback?
- FLEX faculty maintained office hours?
- FLEX faculty invited and welcomed inquiry and provided feedback?

Faculty/ Student Meetings:

- Students accessed Faculty re: academic/ course advice?