Educational Systems Theory Study

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Abstract

In this study, researchers conducted literature reviews to support or invalidate 14 theorems of the Axiomatic-General Systems Behavioral Theory (A-GSBT) as they applied to an educational context. Researchers investigated the following three questions: 1) Which theorems could possibly be applied to educational systems? 2) Are there empirical studies that provide evidence to either validate or invalidate the 14 theorems in an educational context? 3) Does the Systems Theory proposed by Thompson & Frick (2004) adequately describe educational systems? Results of the literature review revealed that 12 of the theorems could be supported based upon the data gathered and 2 of the theorems could not be validated. In addition, while collecting data, the researchers found that the 14 theorems did not appear to be directly applicable to a number of key issues brought up in some empirical studies reviewed. Limitations of the study and implications for future research are explored.

Purpose of Study

The ability to utilize a tool to predict the outcomes in a system during initial planning stages has been incorporated into software games such as SimCity. In SimCity, users can build a city by manipulating different components within the system and then observing the outcomes of their decisions. Software to predict outcomes in an educational system has not yet been developed and Dr. Theodore Frick, an associate professor at Indiana University's Instructional Systems Technology department, has been researching the data necessary to help create such a program, which he termed *SimEd*. Using the general systems theory work being done by Kenneth Thompson, the developer of A-GSBT and head researcher at Raven58 technologies, Frick set out to develop an Educational Systems Theory (EST) which would be helpful in defining algorithms which may form a theoretical basis for simulation software such as *SimEd*.

The purpose of this study was to determine if the 14 theorems of the Axiomatic-General Systems Behavioral Theory (A-GSBT) model are or are not supported by empirical data found within extant research that has been conducted in various educational areas. While A-GSBT was designed to predict the behavior of "intentional systems", or systems that are designed to achieve specific objectives (Thompson, 2004), its applicability in this study was in the context of educational systems. This was conducted by examining and making inferences about data gathered through literature reviews performed by the researchers.

Background

An educational system is described by the relationships among its components (teachers, students, content, and contexts) and the relationship this system has with its environment (Frick, 1991). When changes are made in an educational system, one or more of these relationships can be affected. Yet, reform efforts in education tend not to achieve the desired impact because

change is made in piecemeal, rather than a systemic fashion. An example of this is when one component is changed without consideration for the supporting changes required in other components (King & Frick, 1999).   Systemic change, however, is a comprehensive process where "a fundamental change in one aspect of a system requires fundamental changes in other aspects in order for it to be successful." (Reigeluth, 1992, p. 9) However, changes may also occur on a smaller scale. EST enables these changes to be examined regardless of their magnitude.

Amidst major changes to K-12 schools brought about by the *No Child Left Behind* initiative passed by the U.S. Congress in 2002, the need for systemic change is even more critical. Frick (2004) described a scenario whereby "schools that repeatedly fail to meet current state standards for student achievement will be held accountable" (p. 1). In such a case, parents "will have the opportunity" (p. 1) to send their children to another school that was more successful. A piecemeal approach to change would invariably result in problems with availability of schools and logistics. One recent example of this problem was mentioned in an article in the Chicago Tribune. The newspaper reported that out of 175,000 eligible students in Chicago, only 5,933 applied for a transfer under the No Child Left Behind Act (Dell'Angela, 2004). In anticipation of higher enrollment numbers, schools spent more money to hire extra teachers and textbooks. It was later discovered that less than half of the students expected actually showed up. For those who applied, 438 won lottery spots, but only 200 of these students finally showed up in the schools. One reason cited for the low transfer rates were logistical problems of commuting the child to a school further away from home.

The central difficulty in implementing systemic change in educational systems is the issue of predictability. Frick (2004) argued for the need of an "educational systems theory" (p. 2)

that could "describe, explain and predict whole educational systems and their transactions with societies in which they are embedded" (p. 2). The theory is intended to be used to provide a foundation for the development of an educational systems simulation tool, that Frick has termed *SimEd*. If such a system was available, potential outcomes of educational reforms could be described and predicted before actual implementation. *SimEd* is therefore a tool that enables educational reforms to be planned systemically.

The theoretical basis for SimEd

Maccia & Maccia (1966) were the first researchers who attempted to develop an educational theory which they called the SIGGS Theory Model, by synthesizing four theories: Set, Information, di-Graph, and General Systems. These theories consist of 201 hypotheses describing school systems. Faced with the limitations of linear models in quantitative methods, Frick (1990) used parts of information theory in SIGGS to develop an observation and measurement methodology called Analysis of Patterns in Time (APT). As Frick (1994) explained, APT could be used as an empirical method for the validation of the SIGGS theorems. During this time, Thompson (2004) also extended the SIGGS Theory and developed A-GSBT.

Frick and Thompson found a synergy in their work and began to collaborate in 2001. Frick found that when used in an educational context, A-GSBT theorems could be used to derive an Educational Systems Theory (EST). Frick (2004) therefore proposed that the axioms and theorems of A-GSBT be used as a "rule base for *SimEd*" (p. 5), and APT be used as a "primary research methodology for validating theorems in EST" (p. 6) Currently, A-GSBT theorems have been logically derived from the axioms, and are still being developed. In order to determine the utility of using a formal theory such as A-GSBT to predict empirical systems, a set of 14

theorems, derived from a subset of the axioms which make up A-GSBT, were chosen for this initial evaluation. More support for and empirical testing of these theorems still needs to be conducted to ensure that they comprehensively describe relationships and transactions in educational systems.

Research Questions

As discussed previously, this study is intended to look for support for or against the14 theorems of A-GSBT in terms of an educational context. A-GSBT is a general system theory designed to predict behaviors in "intentional systems". Therefore, it is necessary to review A-GSBT theorems for those that are applicable to educational systems. The 14 theorems were derived by applying rules of logical deductions (Frick, 2004). They are all logically consistent with axioms, however, empirical validations have not yet been conducted. If the empirical data show support for the theorems, then the axioms can be retained. But, if there is no support for the theorems, then theory axioms and definitions should be reviewed, as revisions may be necessary. (Frick, 2004). In this study, three research questions are addressed: 1) Which theorems could possibly be applied to educational systems? 2) Are there empirical studies that provide evidence to either support or not support the 14 theorems in an educational context? 3) Does the Systems Theory proposed by Thompson & Frick (2004) adequately describe educational systems?

Methodology

The primary research methodology for validating the 14 theorems is by finding empirical data through literature review. The literature reviewed includes research from periodical journals, dissertations and education-related news reports. Along with finding empirical data, researchers also reviewed previous research related to SIGGS, A-GSBT, and studies conducted

by applying the APT method. Thompson assisted researchers in clarifying questions surrounding SIGGS and A-GSBT via emails and conference calls.

Empirical data gathered through the literature review was reviewed to determine if the data validated the 14 theorems. For example, Theorem 12, which states that system input increases, only if filtration decreases, is supported by the following evidence. The study written by Crawford (1966) discussed that the students who were offered financial aid were more likely to enter college than those students who were offered no financial aid. In this example, filtration refers to financial aid whereas a system input refers to students who enter college. The author found that by providing financial aid (filtration decrease) more students could enter college (system input increase). This phenomenon is consistent with Theorem 12 and therefore, this provides support for the theorem. Research that validated or invalidated the theorems will be discussed in detail in the next section of this report.

Results

Data compiled from the literature review conducted by the researchers can be found for the specific theorems below. Definitions of A-GSBT terms can be found in Appendix A.

Theorem 12: System input increases, only if filtration decreases.

Data which appears to support this theorem was found in a study by Crawford (1966) which concluded that when financial aid was offered to students, those who were offered were more likely to enter college than those that had no offers. Therefore, there had been a decrease in filtration based on financial needs.

In this example, the cost of college appears to be the filter, and students entering college are viewed as the input. By offering financial aid to students, filtration was apparently decreased for those students.

Theorem 13: System input decreases, only if filtration increases.

Data which appears to support this theorem was found in a study of scholarly journal rejection rates. Hargens (1988) found that more complex peer-review schemes result in higher rejection rates. Therefore, it is likely that the addition of filtration on submitted articles leads to a decrease of accepted articles.

In this example, peer-review processes were the filter for a toput of scholarly journal articles sent in by authors attempting to get them published. More complex review processes seemed to provide increased filtration, and caused the input into the system to decrease.

Theorem 21: System feedthrough increases only if compatibility increases

Data which appears to support this theorem was found in a study by Ferris et al (2004) which analyzed 10 years of graduation rates across major athletic programs in universities. They concluded that when admission policies were more selective, both students and athletes graduate at higher rates.

In this case, feedthrough could refer to the graduation rates of students and athletes. By being more selective during admissions, the university is ensuring that they admit students (feedin) with characteristics for success in the program (feedout). Compatibility is apparently increased by a more stringent admission policy, which in turn appears to ensure higher feedthrough (graduation rates).

Theorem 29: System openness increases only if efficiency decreases

Data which appears to support this theorem was found in a study by Lum (2001). Lum reported the criticism made by the American Bar Association on Texas Southern University (TSU)'s law school, which was found to be admitting academically unqualified students. The Law School Admissions Test score for students admitted to TSU is 142, compared to a national average of 150; and the median GPA ranged from 2.67 to 2.76, compared to a national average of 3.06 to 3.10. As a result of this, TSU's law graduates have an attrition rate of 40% at the state Bar exams, compared to the national average of 9%.

With the lowering of admission criteria, the TSU law school (system) appears to become more open because it is apparently easier to admit students (more feedin). But, the lowering of standards most likely resulted in a decrease in feedthrough, as the number of students who are able to pass the state's Bar exams was reduced. From the article, it is not evident that enrollment has been reduced. Because it appears that enrollment did not change drastically, efficiency is apparently reduced with lower feedthrough.

Theorem 53: System complete-connectivity increases only if flexibility increases

Data which appears to support this theorem was found in a study conducted by Minke & Anderson (2003). In the study, the authors compared communication and anxiety levels during traditional parent-teacher conferences with the family-school conference model. In the parent-teacher conference sample group, parents and teachers both reported having feelings of anxiety over the conference and that parents often felt that conferences were held so that teachers could talk about the student while the parent listened. In the family-school conference sample group,

students were allowed to be an active participant in the conference and teachers would often

encourage the student to communicate thoughts or feelings to their parents and parents were free

to communicate back with the student of the teacher. Feelings of anxiety were also reported to

have been lessened.

In this example, the system may be defined as the classroom. In the traditional conference

model communication between the teacher and parent is mostly unidirectional, and the student

either hears about the conference being held from the teacher or hears what the teacher has said

from their parents. In this case, members of the system are not always communicating directly

with one another and communication is passed from one member to the next (teacher's

comments are mentioned to the student via the parent). In the family-school conference model,

the communication channels apparently increased since all components were allowed to

participate in the activity. Because this flexibility appears to have increased, all members of the

system (teacher, parent, and student) apparently were able to communicate freely with one

another resulting in a likely increase in complete-connectivity.

Data was also found to support Theorem 53 in a study where Harrison (1995) reported a

practicum that was designed to improve communication between teachers, among teachers,

students and parents in an elementary school. The communication partnership was reported to

have been accomplished through the student reading club, student newspaper development

project, home-school interaction homework projects, and several other activities. The student

newspaper was especially designed to connect teachers, parents, and students, and provide

information about school events and activities for all three groups. As a result of various

activities, communication between teachers and among teachers, parents, and students apparently

increased. School records and surveys indicated that 25 out of 27 parents reported receiving

notes and holding conversations with teachers. In addition, 26 out of 30 parents mentioned that they were informed about school activities very well. This implies that the parents not only knew what was happening in schools, but also were aware of the type of work students did and how much teachers assisted students.

In this example, the system can be seen as being comprised of the school community as a whole, which consisted of teachers, parents, and students. Before the communication partnership activities were implemented, the relationships among teachers, parents and students appear to have not been completely connected. Parents appeared to not be knowledgeable about what was going on in the school and in their children's classes, and in the same respect, teachers were not aware of what other teachers were doing within their classrooms. However, through communication partnership projects, it appeared that more ways to communicate were made, resulting in an apparent increase in flexibility. The bi-directional relationships were apparently made among teachers, students and parents, meaning that it is most likely complete-connectivity increased.

Theorem 54: System strongness decreases only if wholeness increases

The case study by Sanders & Harvey (2002) appears to invalidate this theorem. This article describes a case study on an urban elementary school in a high-reform district which developed connections with community business and organizations as well as families in a coordinated program of reform. The study identifies four factors which allowed the school to build these community ties: the school's commitment to learning, the principal's vision, the school's receptivity to involvement by those in the community, and the school's willingness to engage in two-way communication with community partners, allowing various levels and types

of community involvement. The principals and other involved members of the community said that the principal's role in this was very important, but most important was the principal's ability to inspire and encourage others to maintain the partnership. Receptivity and appreciation were reported to have been important and district level support was apparently seen as crucial. Parents, teachers, and community members formed "Action Teams" which allowed them to work together to find solutions for the school.

In this example, the system can be defined as consisting of the principal, teachers, parents, and community members who were working on ways to support the local school system's programs. Prior to the innovation of the Action Team system, parents were more likely to have felt disconnected and the general community appeared to have had little or no involvement in the school. A high level of wholeness is seen within the newly adopted Action Teams, which apparently allowed members of all groups to work together closely. However, the authors highlight that without the leadership of the principal and his direct or indirect involvement with all key players, the innovation would not be successful. Furthermore, all players not directly working together appeared to have needed a mechanism to understand what others were doing. As we can see in this example, it appears that a high level of strongness was needed to apparently encourage a high level of wholeness between all players.

Theorem 55: System strongness increases only if hierarchical-order decreases

Data which appears to support this theorem was found in a study where Izu et al (1996) reported the evaluation outcomes of Hawaii's School/Community-Based Management Initiative (SCBM). The SCBM is designed to delegate decision- making authority to all segments of the school's community, who were represented by principals, teachers, support staff, parents,

students and other community members. The evaluation reported that SCBM made all who were represented by the school's community have a greater voice, particularly those whose voices were previously absent in school decision making. The study stated that new methods of collaboration appeared to have been fostered through SCBM.

In this example, the system could be defined as the school community. Before SCBM was applied, parents, teachers and other community members apparently could not participate in decision making. SCBM appears to have made it possible for all members of the community to participate in decision making and resulted in an apparent decrease in hierarchical order. System strongness most likely increased through collaborative work and active communication among community members.

Theorem 56: System strongness increases only if flexibility increases

Data which appears to support this theorem was found in a report by Green (2003). Green conducted a study to determine what early childhood education centers do to specifically communicate with the fathers of their students since research showed that having both parents actively involved in the education of a child aids in their development. The author conducted a survey on the current practices of the centers and also performed a multiple regression analysis. Findings showed that centers which actively included the father specifically (especially fathers who did not live at the same address as their child) by having the father's name listed on the enrollment form, and centers that actively tried to communicate with the father via mail or by openly invited the father to the school, apparently had a higher rate of paternal involvement at the center than centers that did not implement any of the above listed communication plans.

In this example, flexibility appears to have increased among educational centers that have decided to actively reach out to communicate with the paternal figures within their students' lives. Because of this, fathers of these students were more likely to interact more with the children's schools which therefore implies that there is an increase in strongness.

Data also appears to support this theorem in a study where Geibert (1998) reported that online collaboration tools such as email, video conferencing and chat apparently assisted with collaboration among graduate students and faculty. Before collaboration tools were provided, geographically separated students who were in a nursing distance education program tended to confine collaborative groups to same-site colleagues. However, after several collaboration tools were incorporated into the web-based class, communication between geographically separated students was more likely to occur at any time regardless of time and place.

In this example, the system may be defined as the distance education class. Before collaboration tools were introduced, students tended to communicate only with geographically co-located classmates. Through the implementation of the collaboration tools, such as email, video conferencing and chat, students were more likely to freely communicate with all members of the class directly or indirectly regardless of geographical limitations apparently allowing strongness to increase. Students now appear to have more ways to interact each other, meaning that flexibility most likely increases.

Theorem 57: System unilateralness only if hierarchical-order.

Data which appears to support this theorem was found in a report by Boettieger (1998). In the report, the author cited Bennett & LeCompte's (1990) descriptions of school bureaucracy.

"A modern day educational bureaucracy, within such a system, decision making is centralized and hierarchical. State and district level administrators determine budgets, schedules, curricular content and standard, textbooks, testing programs and content of inservices. Countless rules and regulations from national, state and district level authorities mandate how schools are governed. They stipulate everything from procedures for placing students in special education to which textbooks and materials are to be used at each grade level to when certain test must be administered" (p. 2-3).

Notice that in terms of decision making, an education system is defined by the authors as being centralized and that it has hierarchical order. The communication direction apparently only goes from state level administrators to school systems, implying that the system is unilaterally connected.

Theorem 179: System size increases and complexity-growth is constant only if vulnerability increases

Data which appears to support this theorem was found in a study by Moallem & Micallef (1997). The authors studied six middle schools within a city district in the southeastern United States who created a new Technology Resource Teacher (TRT) position in schools to provide technical and instructional support for teachers to integrate technology into the classroom. It was observed that teachers were not able to integrate technology by themselves as most of them lacked the necessary expertise in Information Technology to do so. A majority of the teachers surveyed agreed that TRTs most likely helped them troubleshoot and solve technology problems.

In this example, vulnerability apparently increased if TRTs were removed because teachers would be less connected and unable to use technology in the classroom. With the

creation of the TRT post, system size appears to have increased as a new component was introduced into the school system. However, with TRTs, complexity growth was apparently constant because the number of connections between teachers and technology problems did not increase.

Theorem 180: System size increases and complexity-growth is constant only if flexibility decreases

Data which appears to support this theorem was found in a study done by The Office of Technology Assessment (1995). They projected that 5.8 million computers would be used in instruction in the spring of 1995. However, they reported computers were only used by 9% of secondary school students for English classes, 6-7% for a math class and 3% for a social studies class. Some of the causes of low usage were apparently due to lack of teacher training on technology integration and barriers to access caused by having computers located in labs rather than in classrooms and "modems located on a central computer in the principal's office" (p. 190).

In this example, system size appears to have increased with the addition of computer systems into schools. However, the usage rate of computers (complexity growth) was apparently constant because teachers could not connect to the computers due to a lack of knowledge and inappropriate locations. Students appear to have less exposure to the computers because teachers do not use them often, therefore, there apparently are less conduits for students to access computers, which is most likely an example of a decrease in flexibility.

Theorem 181: System size increases and complexity-growth is constant only if centrality decreases

Data which appears to support this theorem was found in a study where Twigg (2003) evaluated courses from ten institutions that have been redesigned to incorporate technology for achievement of cost savings and quality achievements. These projects were funded by the Pew Grant program. Rio Salado College's enrollment was increased, but costs were reduced because they employed course assistants to address non content-related questions and to monitor student progress. This apparently enabled instructors to handle more students and to concentrate on academic, rather than logistical interactions with students.

In this example, system size appears to have been increased by increased enrollments and the addition of course assistants. But, when the instructor relegated the logistical interactions to the course assistants, centrality apparently was decreased as the connections to the primary-initiating component (instructor), in terms of logistic support, was reduced. Complexity growth was therefore, implied to be constant since the same instructor was able to handle increased number of students effectively.

Theorem 181 appears to be supported in a study where Cotton (1996) reviewed over 100 research documents that study the relationships between school size and other factors related to education. One of the areas looked at was the effect of school size on administrative costs and the number of administrators needed by schools of various sizes. When looking at the administrative costs of schools of increasing size, researchers discovered that larger schools were not always more efficient. If school size increased from small to medium, the same job could have been done with the same number of administrators. However, if the school's size continued to increase beyond the medium size, additional administrators were needed.

In this example, it appears that complexity-growth initially occurs by having the same number of administrators service a larger number of teachers and students. As the system grows larger, complexity-growth appears to be held constant by adding more administrators to meet the needs of the larger system (the school). When additional administrators are added, apparently centrality would be decreased since a job can no longer be handled by a single person and therefore, there would not be a single point of contact anymore.

Theorem 182: System size is constant and complexity-degeneration increases only if disconnectivity increases

Data which appears to support this theorem was found in a study about the E-rate program. The program, governed by the Federal Communications Commission, was established to disburse funds that helped link public and private schools as well as public libraries to the Internet by paying up to 90 percent of technology costs for wiring and connection fees. (Borja, 2004) reported that a freeze on $3.28 billion in requests for aid under the E-rate program left hundreds of school districts without funding and that had seriously impeded classroom instruction. The article mentioned the Kuspuk school district in Alaska which is:

> "spread out over 1,200 miles. It is accessible only by plane or, in the summer months, by boat on the Kuskokwim River. Because of a tight budget, the district has only a meager number of old textbooks. There is no library in the district, nor in the villages served by the schools. Kuspuk teachers have relied on the Internet to conduct research and gather classroom materials. About 300 computers were connected to the Internet via broadband until Aug. 15. That's when the Internet connection was

turned off, because E-rate money the district planned to use to pay the

broadband fees was unavailable. Now, some teachers are calling the

district office, which has slow Internet access, to look up and download

materials for them" (Borja, 2004, 'Tired and Frustrated' section, ¶ 6-7).

In this case, the system size, or the number of students, teachers, computers, and course

materials at Kuspuk appears to not have changed. Access to the Internet allowed new course

materials to be added to the system. When teachers could not access the Internet, disconnectivity

appeared to rise because the teachers faced an increased chance of being cut off from access to

web-based course materials. The number of connections that teachers had with various types of

course materials also appears to have decreased because teachers could not access web-based

materials without going through the district office. Therefore, this resulted in an apparent

increase in complexity degeneration.

Data also appears to support this theorem in a study conducted by Burk (1996). Burk

studied "looping", the practice of keeping the same teacher with a group of students through the

period of several years. In normal one-year student/teacher cycles, typically one month out of

the school year is seen as "wasted" because teachers spent the time getting to know the students,

evaluating their needs, and drawing out shy students. With looping, according to the teachers

interviewed in the study, this "wasted" time could instead be utilized for more meaningful

activities.

In normal one-year teacher/student relationships, disconnectivity appears to have

occurred after each summer when students had not yet connected with their new teacher.

Although the size of the system apparently was constant (one teacher and a relatively stable

number of children to a class), complexity-degeneration would most likely occur because students had not yet created connections with their new teachers.

Theorem 183: System size decreases and complexity-degeneration increases only if disconnectivity decreases

No examples were found for this theorem. Upon discussion with Ken Thompson, Theorem 183 was determined to be invalid.

Analysis

Data compiled by the researchers show support and validation for 12 of the theorems and two of the theorems, #54 and #183, were found to be invalidated. This was confirmed by having Thompson review and analyze the data that was presented to him.

However, it is important to note that the 14 theorems may not comprehensively explain all educational situations. The 14 theorems explored did not appear to cover some key aspects discussed in the findings of studies encountered during the literature review. Some educational topic areas consistently appeared during the literature review. These topics may be covered by other theorems in A-GSBT or additional theorems may need to be added.

The topics in question were categorized by the team and grouped into 6 categories: student achievement, motivation, teaching methods, interactions between a system and the negasystem, differences in methodologies of the same concept, and threshold conditions involved in the effectiveness of changes to a system. To assist with future research conducted on EST, the researchers have compiled a brief list of research studies examined within each of the 6

categories mentioned above. Appendix B provides an annotated bibliography which includes more details on the studies discussed.

When studying educational reform in various states, student achievement was a key variable being studied, however, none of the 14 theorems were applicable to this topic in education. Research reviewed by the researchers is as follows:

1. Reville (2004) studied the role of high standards and high-stakes testing in the improvements in education in the state of Massachusetts; and its impact on student achievement,

2. Negroni & Iwanicki (2003) studied school improvement initiatives that were implemented to improve student performance on the Connecticut Academic Performance Test (CAPT),

Another educational topic that the 14 theorems could not be applicable to was for research studies that addressed changes in teaching methods. In the following studies, the size of the system did not change, but the impact of different teaching methods was studied:

1. Tu (2000) studied how various strategies could improve social presence of students in an online graduate course,

2. Bozkaya (2001) studied how instruction administered through written and visual symbol systems affected student achievement, confidence and attitudes of distance education students,

3. Odin (2002) studied teaching activities that contributed to a high quality, interactive experience that engage students in online courses conducted by the University of Hawaii,

4. Cavanaugh (2001) saw a variation in student performance when using distance education as opposed to traditional methods depending on subject matter and level of student ability to work independently,

5. Holzinger et al (2001a) explored the use of simulated game-show computer software to tap the effects of "incidental learning" on traditionally uninteresting subject matter for K-12 students.

The two studies below represent research examples found on teacher motivation. The 14 theorems did not appear to specifically address this topic.

1. Hobbs (2004) explores teacher motivation in implementing media literacy programs.

2. Holzinger et al (2001a) explores the motivational benefit of using games to enhance student learning.

Research about interactions between the school system and the negasystem were not supported by any of the 14 theorems. One research example is:

1. Sanders (1999) and Sanders & Harvey (2002) both discussed programs in which parents and the community were brought in to play a role in the educational system (local school district). In all cases studied, the partnerships formed provide additional resources for the school and strengthened bonds between the school, the families, and the community at large.

None of the 14 theorems were applicable for research studies where different methodologies of the same concept were used to affect another component within the system. An example of this type of study is:

1. Barron et al (2003) discussed the differences in the amount of use of technology depending on the type of use, the grade level, and the subject area taught by K-12 teachers.

In some works reviewed, there appeared to be threshold conditions involved in the effectiveness of changes to a system. None of the theorems we looked at addressed these conditions. An example is as follows:

1. Sanders (1999) conducted a study where he reported that a three-year period was needed for an established partnership to be set up between parents, school, and community and if a lesser period was used, the partnership may not succeed or may not see the same success as the three-year period observed.

Limitations of Study

While the researchers attempted to provide general background data for the support of EST, there were a few limitations to the study. Due to time constraints, researchers were not able to set up individual empirical studies for each theorem to see whether or not studies conducted would possess the predictive outcome for the specific theorem. Because of this, no empirical observations were done by the researchers and instead, a literature review was conducted to find examples to support each theorem. Researchers were able to find one or two studies to support each theorem, however, the researchers did not systematically plan to locate examples in disciplines and aspects in educational systems, therefore, the results are not generalizable to all educational systems situations.

At times, it was difficult to see the complex relationships in the empirical studies because the authors of the empirical studies were not looking specifically for the relationships predicted

by A-GSBT. For example, it appears that there is a complex relationship between system size and system complexity (which may have caused some confusion when exploring Theorem 181). As the size of a system increases, complexity growth appears to remain constant in order to maintain the same level of connectedness between components. This aspect was not described very clearly in the examples studied. Further empirical research into the exact nature of the connection between complexity growth and system size could be valuable.

Another limitation was that the researchers discovered categories of research topics which were not addressed by any of the 14 theorems. These topics may be applicable to other theorems, however, research into this is beyond the scope of this study and is recommended for future research.

The researchers decided that the best approach towards looking for data would be to search for data by looking within categories they felt would most likely have examples that could support or invalidate the 14 theorems. There was no standardized process established for conducting the literature review or evaluation of the research studies however, and this makes the literature review process itself a limitation of this study. Furthermore, the studies available may not have been focused on the areas researchers were focused on and some studies only tangentially touched on issues which matched with the theorems researchers were attempting to evaluate.

Furthermore, although theorems may be logically sound, it is empirically possible to invalidate a theorem with a single piece of evidence, and no amount of supporting evidence can conclusively prove a theorem to be correct. However, a preponderance of evidence would provide strong support for A-GSBT as a whole, and the theorems investigated in particular. The initial validating evidence presented in this study can suggest ways in which the set of theorems

may be used to analyze or predict educational system behavior, but should not be seen as validation of the theorems or the system as a whole.

Finally, it is important to note that the theorems and terms used during this study are still under development. The mathematical model used is currently being modified and researchers were working with a subset of the planned theorems. Therefore, the issues brought up in the analysis section should be looked at in relation to the remaining theorems in order to determine whether the complete theorem set will be predictive for all aspects of educational systems.

Conclusions and Suggestions for Future Research

The researchers of this study have been able to initially provide support for 12 of the A-GSBT theorems in order to help provide background data for EST and the future development of *SimEd*. There is still much research that needs to be done on EST and this study only intends to provide evidence that the development of theorems is progressing in the right direction, and the study should not be viewed as an overview of the entire system of proposed theorems.

In order to ensure that the theorems hold true across all contexts, the researchers recommend that more studies be done to search for examples of research studies that support or invalidate theorems. In addition, the researchers also recommend that theorems be tested against real-life data through controlled, empirical studies in various contexts. Studies conducted in this manner could allow the specific features of the theorem to be carefully monitored and could give support to or invalidate the theorems more directly. In summary, the researchers believe that the data collected on the theorems provides a good background for the development of EST and *SimEd*. They also believe that the data presented in this paper, along with future research studies,

will help bring Frick and Thompson closer to the full realization of a dream which began 10 years ago.

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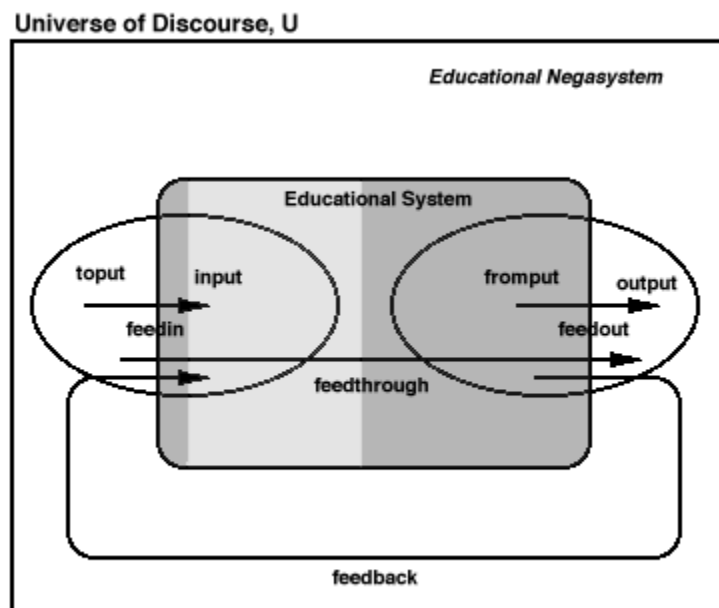
Appendix A: Dictionary Terms

Universe of Discourse, U

Educational Negasystem

Educational System

toput   input   fromput   output

feedin   feedout

feedthrough

feedback

Figure 1

SIGGS Theory Model. (1995). Property: Educational System Feedback. Retrieved on December 11, 2004 from
http://www.indiana.edu/~tedfrick/feedback.html

PATH CONNECTEDNESS
A-GSBT Definition: the ability to go from one component to another by means of a "path," that is, a "directed path" (K. Thompson, personal communication, December 8, 2004).
Definition as it relates to an educational system: People, concepts, or objects that are connected within the same educational system
Examples: Communication channels between administrators, teachers, and students.

SYSTEM PROPERTIES

EDUCATION SYSTEM
A-GSBT Definition: a *group* with at least one affect relation (Thompson, n.d.)

$$\mathbb{S} =_{df} (\mathcal{G}_0, \mathcal{A}) = (\mathbb{S}_0, \mathbb{S}_\phi)$$

Definition as it relates to an educational system: A system of teachers, students, content and context.
Examples: A classroom or school or school district or the higher education system can be defined as education systems.

NEGASYSTEM
A-GSBT Definition: No A-GSBT definition stated (Thompson, n.d.)

Definition as it relates to an educational system: All parts of the environment outside of the education system

Examples: If you define the system as being a school, then the negasystem would be the community the school is located in.

PUT PROPERTIES

INPUT

A-GSBT Definition: $\mathbf{I}_{p}$, $=_{df}$ *system* components whose value-set of the toput system control-qualifiers is "true" (Thompson, n.d.).

$$\mathbf{I}_{p} =_{df} \{\varkappa|\ \varkappa\in\mathbb{S}_{0} \land \exists P(\varkappa)\in\mathscr{L}_{C}\ \exists\mathcal{A}_{i}\in\mathcal{A}\,[\{\{\varkappa\},\{\varkappa,P(\varkappa)\}\}\in\mathcal{A}_{i} \land P(\varkappa) = \mathsf{T}\mid {}_{T/I}\mathbb{S}]\}.$$

Definition as it relates to an educational system: A person, concept, or object that is allowed into the education system after a process of filtration.

Unit of measurement: Numerical count or rate

Example: People, ideas or materials. For example, in Crawford (1966), number of students was the inputs to the system.

OUTPUT

A-GSBT Definition: $\mathbf{O}_{p}$, $=_{df}$ *negasystem* components whose value-set of the fromput negasystem control-qualifiers is "true" (Thompson, n.d.)

$$\mathbf{O}_{p} =_{df} \{\varkappa|\ \varkappa\in\mathbb{S}'_{0} \land \exists P(\varkappa)\in \mathscr{L}'_{C}\ \exists\mathcal{A}_{i}\in\mathcal{A}\,[\{\{\varkappa\},\{\varkappa,P(\varkappa)\}\}\in\mathcal{A}_{i} \land P(\varkappa) = \mathsf{T}\mid {}_{F/O}\mathbb{S}]\}.$$

Definition as it relates to an educational system: A person, concept, or object that is allowed out of the education system (into the negasystem) after a process of filtration.

Unit of measurement: Numerical count

Example: People, ideas or materials.

TOPUT

A-GSBT Definition: $\mathbf{T}_{p}$, $=_{df}$ *negasystem* components that result in a value-set of the system control-qualifiers (Thompson, n.d.).

$$\mathbf{T}_{p} =_{df} \{\varkappa|\ \varkappa\in\mathbb{S}'_{0} \land \exists P(\varkappa)\in\mathscr{L}_{C}\ \exists\mathcal{A}_{i}\in\mathcal{A}\,[\{\{\varkappa\},\{\varkappa,P(\varkappa)\}\}\in\mathcal{A}_{i}\mid {}_{T/I}\mathbb{S}]\}.$$

Definition as it relates to an educational system: A person, concept or object attempting to enter the education system from a negasystem (e.g. work or society) or another education system in order to participate in or be used by the education system.

Unit of measurement: Numerical count

Example: People, ideas or materials.

FROMPUT

A-GSBT Definition: $\mathbf{F}_{p}$, $=_{df}$ *system* components that result in a value-set of the negasystem control-qualifiers (Thompson, n.d.).

$$\mathbf{F}_{p} =_{df} \{\varkappa|\ \varkappa\in\mathbb{S}_{0} \land \exists P(\varkappa)\in \mathscr{L}'_{C}\ \exists\mathcal{A}_{i}\in\mathcal{A}\,[\{\{\varkappa\},\{\varkappa,P(\varkappa)\}\}\in\mathcal{A}_{i}\mid {}_{F/O}\mathbb{S}]\}.$$

Definition as it relates to an educational system: A person, concept, or object attempting to leave the education system and enter the negasystem (work, society or another educational system).
Unit of Measurement: Numerical Count
Example: People, ideas or materials. Student applying for graduation.

FEED PROPERTIES

FEEDIN
A-GSBT Definition: f_I, $=_{df}$ transmission of negasystem *toput* to system *input* (Thompson, n.d.).

$$f_I =_{df} \sigma \mid \exists P(\textbf{x}) \in {}_{T_p}\mathcal{L}_C \wedge [\exists \mathcal{A}_m \; \forall \{\{\textbf{x}\},\{\textbf{x},P(\textbf{x})\}\} \in \mathcal{A}_m \in \mathcal{A} \; (\sigma: T_p \times {}_{T_p}\mathcal{L}_C \rightarrow I_p)]$$

Definition as it relates to an educational system: The process where toput is successfully processed into input of the education system. A filter may or may not be utilized during the feedin process
Measurable Unit: No measurable unit
Example: Students who are currently in the eighth grade are defined as the toput. Students who successfully complete all requirements (filtration) necessary to pass the eighth grade are then promoted to ninth grade through the feed in process. Upon entering the ninth grade, they are now the input. Therefore, the process of moving from junior high to high school is the feedin process. Another example is in Ferris et al (2004), where feedin refers to incoming freshmen.

FEEDOUT
A-GSBT Definition: f_O, $=_{df}$ Transmission of system *fromput* to negasystem *output* (Thompson, n.d.).

$$f_O =_{df} \sigma \mid \exists P(\textbf{x}) \in {}_{F_p}\mathcal{L}'_C \wedge [\exists \mathcal{A}_m \; \forall \{\{\textbf{x}\},\{\textbf{x},P(\textbf{x})\}\} \in \mathcal{A}_m \in \mathcal{A} \; (\sigma: F_p \times {}_{F_p}\mathcal{L}'_C \rightarrow O_p)]$$

Definition as it relates to an educational system: The process in which fromput is successfully converted into output of the educational system.
Measurable Unit: No measurable unit
Example: In Ferris et al (2004), feedout is exemplified by the graduates

FEEDTHROUGH
A-GSBT Definition: f_T, $=_{df}$ transmission of negasystem *toput* through a system to negasystem *output* (Thompson, n.d.).

$$f_T =_{df} \sigma \mid \sigma(\textbf{x}) = (f_O \circ f_N \circ f_I)(\textbf{x})$$

Definition as it relates to an educational system: The process of allowing toput all the way through the education system and becomes and output to the next system or (toput for the next system). Feedthrough = feedin and feedout.
Measurable Unit: No measurable unit

Example: Ferris et al (2004), feedthrough is exemplified by the graduation rates of students and athletes.

FEEDBACK
A-GSBT Definition: f_B, $=_{df}$ transmission of system *fromput* through a negasystem to system *input* (Thompson, n.d.).

$$f_B =_{df} \sigma \mid \sigma(\mathbf{x}) = (f_I \circ f_E \circ f_O)(\mathbf{x})$$

Definition as it relates to an educational system: The process in which an education system outputs back to itself.
Measurable Unit: No measurable unit
Example: A student attends Indiana University (the educational system) as a graduate student, and upon graduation becomes hired as a faculty member of Indiana University. Documents such as the school newspaper are published by students/faculty of a junior high school and these documents are read by students/faculty of the same school.

FILTRATION PROPERTIES

FILTRATION
A-GSBT Definition: $_S\mathscr{F}$, $=_{df}$ the set of toput system-control qualifiers that preclude *feedin* of *toput* (Thompson, n.d.).

$$_S\mathscr{F} =_{df} \{P(\mathbf{x}) \mid P(\mathbf{x}) \in _{T_p}\mathscr{L}_C \wedge [\exists \mathcal{A}_m \forall \{\{\mathbf{x}\}, \{\mathbf{x}, P(\mathbf{x})\}\} \in \mathcal{A}_m \in \mathcal{A} (\sigma_\mathbf{x}: T_p \times _{T_p}\mathscr{L}_C \rightarrow T_p)]$$

Definition as it relates to an educational system: Parameters or criteria imposed by the education system to determine if a person, concept, or object in toput can be allowed into it and be defined as input.
Measurable Unit: No measurable unit
Example: In Crawford (1966), an example of filtration is the cost of tuition.

Other Properties
COMPATABILITY
A-GSBT Definition: $\mathscr{C}$, $=_{df}$ is a measure of the commonality between feedin and feedout (Thompson, n.d.).

$$\mathscr{C} =_{df} \mathcal{M}(\mathscr{C}) = \mathcal{A}_\mathbf{x}(f_O) \div \mathcal{A}_\mathbf{x}(f_I)$$

Definition as it relates to an educational system: The extent to which feedin is similar to feedout of the education system
Measurable Unit: No measurable unit
Example: In Ferris et al (2004), compatibility refers to the commonality between the characteristics of students admitted and those who would succeed in the program.

Appendix B: Annotated Bibliography

Barron, A. E., Kemker, K., Harmes, C. & Kalaydjian, K. (2003). Large-Scale Research Study on Technology in K-12 Schools:Technology Integration as it Relates to the National Technology Standards. *Journal of Research on Technology in Education*. 35(4). 489-508.

Between 1995 and 2002 the United States student:computer ratio has risen from 10.1 to 5.4 students to a computer, and between 1994 and 2002, the percentage of public schools with internet access has risen from 35% to 99%. 87% of classrooms had internet access in 2001. This study researches the extent to which teachers were using technology and the need for instructional integration of technology in K-12 classrooms to meet new government standards. Most of these standards focus on "technical literacy" rather then specific technical skills. Several technology implementation strategies are discussed.

In this study, implementation is measured in a large school district across Elementary, Middle, and High School, across subject areas (English, Math, Science, and Social Studies were measured), and by use in the following four areas: Problem-Solving Tool, Communication Tool, Productivity Tool, and Research Tool. There was quite a large degree of variation across these areas. For instance, elementary schools have computers integrated into the classroom more then middle- or high-school (perhaps because these schools have separate computer areas?), science teachers use it much more then English teachers and somewhat more then math and social studies teachers, and computers are used more for communication purposes then for problem solving across all schools and subject areas, with "productivity" and "research" generally averaging between communications and problem solving in use.

Biddle, B. J. & Berliner, D. C. (2002). Small Class Size and Its Effects. *Educational Leandership*. 59(2). 12-24.

The authors examine a number of large-scale initiatives in the United States aimed at class size reductions. They conclude that class size reductions have varying effects depending on circumstances. Small class size is most beneficial in the early grades, especially for those who have traditionally been disadvantaged. Improvement gained in early grades is retained later on. Extra gains are larger if the class has fewer then 20 students. Gains are only seen in situations where the program is planned carefully and adequately funded. Studies on small class size in upper grades are inconclusive.

Bozkaya, M. (2001). Effects of Instruction Administered through Written and Visual Symbol Systems on the Achievement of Formal and Distance Education Students. Paper presented at the National Convention of the Association for Educational Communications and Technology (Atlanta, GA). Retrieved December 11, 2004 from ERIC Database.

The author examined how written and visual symbols system affected achievement, confidence, attitudes, time-on-task and retention of 161 undergraduate students in Turkey. He found that distance students were performed better in terms of achievement

with both written and visual symbol systems, while face-to-face students were more successful using materials with only written symbols. Visual symbols also had a positive relation to student confidence in both settings. Students who used both written and visual symbol systems spent more time-on-task but developed better attitudes.

Cavanaugh, C.S. (2001). The Effectiveness of Interactive Distance Education Technologies in K-12 Learning: A Meta-Analysis. *International Jl. of Educational Telecommunications*, 7(1), 73-88. Retrieved December 5, 2004 from http://www.unf.edu/~ccavanau/CavanaughIJET01.pdf

Analyses 19 studies on K-12 distance education. For all areas except for foreign languages, distance education courses resulted with equal or slightly higher student performance then traditional classrooms. Their benefits include the flexibility to meet specific student needs, expanded resources, and low-cost alternatives for students, as well as allowing them to work together with others and gain specialized knowledge. However, students must use their own initiative since there is less supervision.

Students saw a moderate increase in achievement for Mathematics, a statistically negligible increase for Science, Social Studies, and Language Arts, and a negative influenced when distance education was used for Foreign Languages in this study. The author concludes that achievement for students using distance education techniques is at least comparable to traditional education, with the benefit of flexibility. He anticipates a rise in distance education for K-12 in the future, and is hopeful that more studies will be done in this area.

Dharmadasa, I. (1995). Class Size and Student Achievement in Sri Lanka. Retrieved November 23, 2004, from ERIC database.

The author investigated the effect of class size on Sri Lankan 4th grade students' achievement based on pre- and post- tests. Class size varied between 20 and 50 students. The study revealed that class size did not have an effect on student achievement. The strongest predictor of achievement appeared to be the socio-economic makeup of the class. Interviews with teachers and principals indicated that more resources, teacher material and instructional practices may also play a role.

Hobbs, R. (2004). A Review of School-Based Initiatives in Media Literacy Education. *American Behavioral Scientist.* 48(1). Sage Publications.

Explores teacher motivation in implementing media literacy programs for their K-12 students. Teachers tend to implement these programs for two reasons: to foster students' creativity and self-expression, and to help students explore economic, political, cultural, and social issues. Others discover media while trying to motivate student's attention and interest in their subject areas. Although some teachers merely have their students analyze films, newspapers, and internet resources, others have begun to emphasize the need for students to create their own media texts. This has spurned action by teacher organizations as well as state-wide and district-level initiatives. Although researchers

have begun evaluating the effectiveness of media literacy programs in schools, few studies have yet been published. There are also many factors which inhibit teachers from implementing instruction as it is designed. Teachers and the general public question whether resources and time should be moved to media literacy programs. The author suggests unifying educational goals to focus on appropriate technology use for the "information age". He suggests a focus on the development of critical thinking, communication, collaboration, and creativity in students, rather then the "tool focus" of the 1990s.

Holzinger, A., Pichler, A., Almer, W., Maurer H. (2001a). *TRIANGLE: A Multi-Media test-bed for examining incidental learning,motivation and the Tamagotchi-Effect within a Game-Show like Computer Based Learning Module*. Retrieved on December 11, 2004 from http://www.iicm.edu/iicm_papers/triangle.pdf .

This article studies the use of Game-Show-like web-based training environments to help children learn, by focusing on a case study of "TRIANGLE", a computer game where players need to gain knowledge to win. The game is very linear and played on a time limit. A diverse set of avatars is available, and multi-media attractiveness is a key goal. The module must provide value and have measurable results which can be compared across uses. The inspiration for this strategy comes from the phenomena of "incidental learning" seen in game-show viewers. The authors cite works which indicate that incidental learning may in some cases be more effective then intentional learning, and desire to understand the causes of this, which appear to be related to motivation. Virtual beings (inspired by the popular Tamagotchi game) are kept happy if their owners answer questions correctly.

The study of the program included groups of ten students using notebook computers in a classroom setting. Students showed a high level of motivation and learning, including incidental learning from information provided via "hyperlinks" as the learner builds a network of facts to win the game.

McRobbie, J. (1996). Focus on California's Class-Size Reduction: Smaller Classes Aim to Launch Early Literacy. *West Ed*. San Fransisco. Retrieved November 23, 2004 from ERIC database.

This article looks at the effects of California's Class Size Reduction program. Benefits of class size reduction include allowing less rigidly structured classroom management techniques, individualized lessons for each student, and more one-on-one teacher-student interaction. However, as the state of California implemented a class size reduction, other problems arose. In addition to the cost of adding teachers and classroom space, there was a shortage of qualified teachers. Schools had to hire less experienced teachers as well as uncertified teachers to make up the difference. Many teachers continued to teach on a "large class" model even when classroom size had been reduced. The author suggests a more comprehensive approach to the problem, which includes focusing on the schools which need change the most, teaching teachers to improve student-teacher interactions,

focusing on student attendance, social and emotional factors, and setting up collaborations with the community and parents as an alternative to adding teachers.

Negroni, I. A. & Iwanicki, E.F. (2003). *An Exploration of How School District Leaders Are Responding to the Connecticut Academic Achievement Test (CAPT)*. Paper presented at Annual Meeting of the American Educational Research Association (Chicago, IL). Retrieved December 11, 2004 from ERIC Database.

The author studied the strategies implemented by school district leaders in Connecticut to improve student test-scores on the Connecticut Academic Achievement Test (CAPT). 253 principals responded to a survey. It was found that the need to improve test-scores has resulted curriculum revisions and the need to develop rubrics for holistic scoring. While the CAPT is not yet widely recognized as a "benchmark assessment" for students, teachers or parents, administrators and teachers have began to incorporate the requirements of the CAPT in their annual planning process.

Odin, J. K. (2002). *Teaching and Learning Activities in the Online Classroom: A Constructivist Perspective.* Paper presented in ED-MEDIA 2002 World Conference on Educational Multimedia, Hypermedia & Telecommunications. Proceedings (Denver, Colorado). Retrieved December 11, 2004 from ERIC Database.

The author studied the online courses conducted through the University of Hawaii's Asynchronous Learning project to determine strategies that contributed to high quality interaction and student engagement. It was found that when students tend to be more engaged if teachers used multi-modal strategies which include group projects, online discussions and facilitative discourse. Multi-modal strategies also enhance perception of teacher presence and "shapes the learning environment" which in turn affects student learning.

Reville, S. P. (2004). *High Standards + High Stakes = High Achievement In Massachusetts. Phi Delta Kappan, 85(8)*, 591-597.

The author argues for the need of "high-standards" and "high stakes" in education systems. The Massachusetts Education Reform Act of 1993 resulted in the setting up of state-wide learning standards that specify the knowledge and skills that students need to achieve at each grade level. The Massachusetts Comprehensive Assessment System (MCAS) is a state-wide testing process that evaluates student achievement of the learning standards. The stakes for achievement at these state-wide tests are now raised because students must achieve a competency determination on MCAS in English & mathematics as a prerequisite for obtaining their diplomas. The author cites examples of how mathematics test-scores of students have improved. Students also outscored other states in writing, reading, Advanced Placement Tests and SAT. The author concludes that raising expectations will better prepare children to succeed in life.

Sanders, M. G. (1999). Schools' Programs and Progress in the National Network of Partnership Schools. *Journal of Educational Research.* 92(4) 220-230.

This study looks at the results of the National Network of Partnership Schools, which has been working with 202 schools since 1996 to create programs of school, family, and community partnerships. Each school agreed to use a framework of six types of involvement, which helped parents help their children at home, volunteer at school, and become involved at school, as well as a plan for collaborating with the community at large to gain resources and services for the school and families who have children at school. This study looked at which schools were doing well with the program and which were not, and the factors involved. According to the study, "excellent" programs were linked to school improvement goals as well as the other criteria.   It was found that support from school, families, and community members who were NOT part of the "Action Team" was important. Schools also benefited from using the network handbook. Schools with Title I funds did better then those without additional funds. Schools found that parent involvement rose based on the partnership efforts, and that the relationship between parents and teachers improved. Members agreed that at least a 3-year commitment was necessary in order to make the initiative work.

Sanders, M. G. & Harvey, A. (2002). Beyond the School Walls: A Case Study of Principal Leadership for School-Community Collaboration. *Teachers College Record.* 104(7). 1345-1368.

This article describes a case study on an urban elementary school in a high-reform district which developed connections with community business and organizations as well as families in a coordinated program of reform. The study identifies four factors which allowed the school to build these community ties: the school's commitment to learning, the principal's vision, the school's receptivity to involvement by those in the community, and the school's willingness to engage in two-way communication with community partners, allowing various levels and types of community involvement.   The principals and other involved members of the community said that the principal's role in this was very important, but most important was the principal's ability to inspire and encourage others to maintain the partnership. Receptivity and appreciation were important. District level support was seen as crucial.

Sharp, M. A. (2003). *Summary of an Analysis of Pupil-Teacher Ratio and Class Size: Differences That Make a Difference and Its Implications on Staffing for Class-Size Reduction.* Paper presented at the 2003 Conference Within a Convention, American Association of School Administrators.

This study clarifies the differences between "class-size reduction" (CSR) and "pupil-teacher ratios" (PTR) by performing a literature review and a survey. The terms are often misused by other studies, which may cause confusion in the varying results on student achievement and other factors when schools attempt to implement changes. Class size reduction (the reduction of the actual number of students assigned to a teacher in a classroom) has been found to have a significant impact to student achievement and motivation, while the pupil:teacher ratio (the ratio of students to certified teachers present in a school building) does not necessarily improve performance or motivation. The author warns that "actual" class size (the number of students on a teacher's attendance

book is not the same as "average" class size (the total student enrollment in a grade level or building divided by the number of general education classroom teachers hired within that unit).

Tu, C. H. (2000). *Strategies to Increase Interaction in Online Social Learning Environments*. In: Society for Information Technology & Teacher Education International Conference: Proceedings of SITE 2000 (San Diego, California). Retrieved December 11, 2004 from ERIC Database.

The author studied how social interaction relates to online interaction in a graduate level course on the Internet for teachers at Arizona State University. Through both qualitative and quantitative analyses, the author found that strategies in three dimensions i.e. social context, online communication and interactivity, affected social presence in the class.