Formative Evaluation of Students at Quest to Learn

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Abstract

Quest to Learn (Q2L) is a public school that opened in 2009 to respond to the needs of kids who are growing up in a highly networked, globally competitive and complex world. The school was designed to include a game-based pedagogy that provides a dynamic, interdisciplinary curriculum, as well as immersive, challenge-based learning experiences. The present article reports the findings from a 20-month evaluation of Q2L. This research was launched when the school opened, with the main goal to identify and assess a set of key student competencies that are relevant and important to Q2L. This student-level evaluation focused on students' development of three core skills (i.e., systems thinking, time management, and teamwork) over the 20-month time period. We found that students significantly improved their systems thinking skills over the duration of the study, and improved (albeit, not significantly) on their time management and teamwork skills as well.

Keywords: assessment, evidence-centered design, game-based pedagogy

Formative Evaluation of Student Learning at Quest to Learn

Much education today is monumentally ineffective. All too often we are giving young people cut flowers when we should be teaching them to grow their own plants. J. W. Gardner

Children growing up in the 21st century need to be able to think differently from kids in past generations. When confronted with complex problems, they need to be able to think creatively, systemically, critically, as well as work collaboratively with others (e.g., Resnick 2007; The Partnership for 21st Century Skills 2006). In contrast to these needs, current educational practices typically adhere to outdated theories of learning and pedagogy, evidenced by a so-called "content fetish" (Gee 2005). That is, schools focus on increasing students' proficiency in traditional subjects such as math and reading, via didactic approaches, which leaves many students disengaged. Schools that depart from the entrenched pedagogy are the exception to the rule.

Quest to Learn (Q2L) is one of these exceptions. Q2L was designed to respond to the needs of kids who are growing up in a digital, information-rich, globally competitive and complex world. Designed to serve students in grades 6-12 school, the school currently houses about 240 students in grades 6-8, and will add one grade each year until full capacity is reached in 2015 with approximately 560 students. It opened in 2009 as a regular (non-charter) New York City Department of Education public school in Manhattan's Community School District 2. Students are selected through an open lottery system; admission is not based on prior academic achievement. A sister school to Q2L, called ChicagoQuest, which uses its game-based curricular model, opened in Chicago in 2011. Both schools are intended to enable all students, regardless of their academic or personal challenges, to contribute to the design and innovation necessary to meet the needs and demands of a global knowledge society. The model provides a learning environment that includes a dynamic, interdisciplinary curriculum, as well as immersive, challenge-based learning experiences (Salen, Torres, Wolozin, Rufo-Tepper, and Shapiro 2011). Towards that end, the model's culture and pedagogy aim to foster deep curiosity for lifelong learning as well as a commitment to social responsibility, and respect for others and self. For more, see http://q2l.org/.

Background: Q2L Curriculum and Assessment

The Q2L curriculum is inspired by the notion that learning is not simply an individualized affair, but a highly social, context-dependent and collaborative achievement (e.g., Bransford, Brown, and Cocking 2000; Lave and Wenger 1991; Vygotsky 1978). Q2L uses a systems-thinking framework as a core curricular and pedagogical strategy. Systems thinking is defined as a holistic perspective that sees the world as increasingly interconnected and can be understood as progressively interconnected, from elemental components to complex systems of activity (e.g., Assaraf and Orion 2005; Barak and Williams 2007; Forrester 1994; Ossimitz 2000; Salisbury 1996). This broad definition includes social, natural, and technological systems that can be studied and understood as having certain cross-cutting commonalities, such as rules, goals, and particular behaviors.

The school also employs a game-based pedagogy, designed by teachers, professional game designers, curriculum directors, and other content experts. Collectively, they create a series of 10-week "missions" (i.e., units of study) which comprise an immersive world in which students take on various identities—from cartographers to architects to zoologists—to solve design and systems-based problems.

Beyond simply employing games to teach, Q2L uses the internal architecture of games to create gamelike learning environments, whether they are analog or digital. Games instantiate constrained systems of activity (or worlds) in which players engage mediational tools, other players, and rule sets to achieve clearly defined winning (or goal) conditions. This requires players to enact specific game behaviors. These behaviors in the gaming world are called core mechanics, which players must perform to successfully complete a game. In the classroom, similar behaviors are required to successfully acquire new knowledge and skills.

To suit the needs of the 21st century, learning environments should reflect knowledge domains (or discourse communities) that reflect the epistemology of current real world professional and/or industry domains. That is, learners should be offered opportunities to apply the actual kinds of knowledge, skills, values, and behaviors (i.e., core mechanics) needed to participate in the domain of, say, U.S. history, journalism, or cellular biology. Learners should be offered genuine and ample opportunities to produce and iterate on content endemic to real knowledge domains. In other words, students should be learning to grow their own flowering plants, in line with our opening quote. Q2L strives to create meet these goals. Moreover, Q2L students are provided with (and often establish on their own) communities of practice where they can collaborate and informally (or formally) share their work with a community of peers (as well as with teachers, game and curriculum designers, as warranted). Similarly, the gamelike curriculum at Q2L is intended to engage students in collaborations with others to complete various tasks. Many quests (i.e., smaller units of a mission) are designed for students to work with others by integrating different types of expertise and providing ongoing feedback to each other.

The school also employs a distinctive approach to assessment. The basic principle of assessment at Q2L is that assessment should be embedded within learning and it should exist *in situ*—located in the discourse and actions of students and teachers (Salen, Torres, Wolozin, Rufo-Tepper, and Shapiro 2011). Therefore, students' knowledge and performance is currently assessed at Q2L by holistic and qualitative techniques such as interviews and observations. As part of the original design documents, Q2L has three learning dimensions—civic and social-emotional learning, design, and content—that guide the curriculum and assessment.

Table 1 Three Learning Dimensions of Q2L

Dimension 1: ***Civic & Social-Emotional Learning***	**Dimension 2:** ***Design***	**Dimension 3:** ***Content***
Learning from peers and others	Systems Thinking	Code Worlds
Planning, organizing, adapting, and managing goals and priorities	Iteration	Wellness
Persisting to overcome complex challenges	Digital media tool use	The Way Things Work

Table 1 (adapted from Salen, Wolozin, Rufo-Tepper, and Shapiro 2011) depicts some of the specific and valued competencies that undergird and frame Q2L. Assessment in Q2L does not focus only on how much a student knows the content, but rather, how she *uses* what she knows while displaying other important 21st competencies (e.g., systems thinking, teamwork, and time management skills).

Research Approach

Quest to Learn redefines what a school looks like, feels like, and what kids need to learn to succeed—at school and life. Ultimately, Q2L may be able to provide a new school model for 21st century learning. Before the model is applied more broadly, we first need to answer some important questions. For instance, how do we define what comprises "success" at Q2L? How do we know if (and to what degree) Q2L is accomplishing its goals? Our 20-month study (September 2009 – May 2011) was implemented as a preliminary attempt to answer these questions related to Q2L. The answer to the first question, concerning the identification of important school-level variables, was described elsewhere (see Shute and Torres, 2012). Our second question examines growth in focal student-level variables and is the focus of the present paper.

We set up our study to coincide with the school opening in September 2009. Our main research goal herein was to identify and assess a set of key student competencies that are relevant and important to Q2L.

Student-Level Evaluation

The purpose of this paper is to report the results of our assessment of specific 21st century competencies that have been identified as being important to the school. We periodically assessed the following three competencies during the 20-month period: (1) systems thinking skill, (2) teamwork (i.e., learning from peers and others), and (3) time management skill (i.e., planning, organizing, and managing goals and priorities).

We selected these three competencies because (a) they were identified in the original Q2L design documents as core competencies that the school intended to support (see Table 1), (b) they were consistently identified by QL stakeholders/interviewees and were included in the school objectives model (see Shute and Torres, 2012), and (c) validated assessment instruments for these three competencies already exist. Each of these competencies has its own set of facets. Figure 1 (1a, 1b, 1c) shows the three competencies and their facets.

Our assessment for the systems thinking skill (Figure 1a) is based on the protocol employed by Sweeney and Sterman (2007). For the teamwork model (Figure 1b), we synthesized research described by the following: Rysavy and Sales (1991); Tindale, Stawiski, and Jacobs (2008); Totten, Sills, Digby, and Russ (1991); Van den Bossche, Segers, and Kirschner (2006); and Zhuang, MacCann, Wang, Liu, and Roberts (2008). The three-factor solution shown in Figure 1b has been consistently reported for this variable relative to middle- and high-school students (see Zhuang et al., 2008). Finally, our time management model (Figure 1c) was based on the findings of Liu, Rijmen, MacCann, and Roberts (2009); MacCann, Duckworth, and Roberts (2009); Macan, Shahani, Dipboye, and Phillips (1990); and Roberts, Schultze, and Minsky (2006). This two-factor solution has been reported relative to middle-school students.

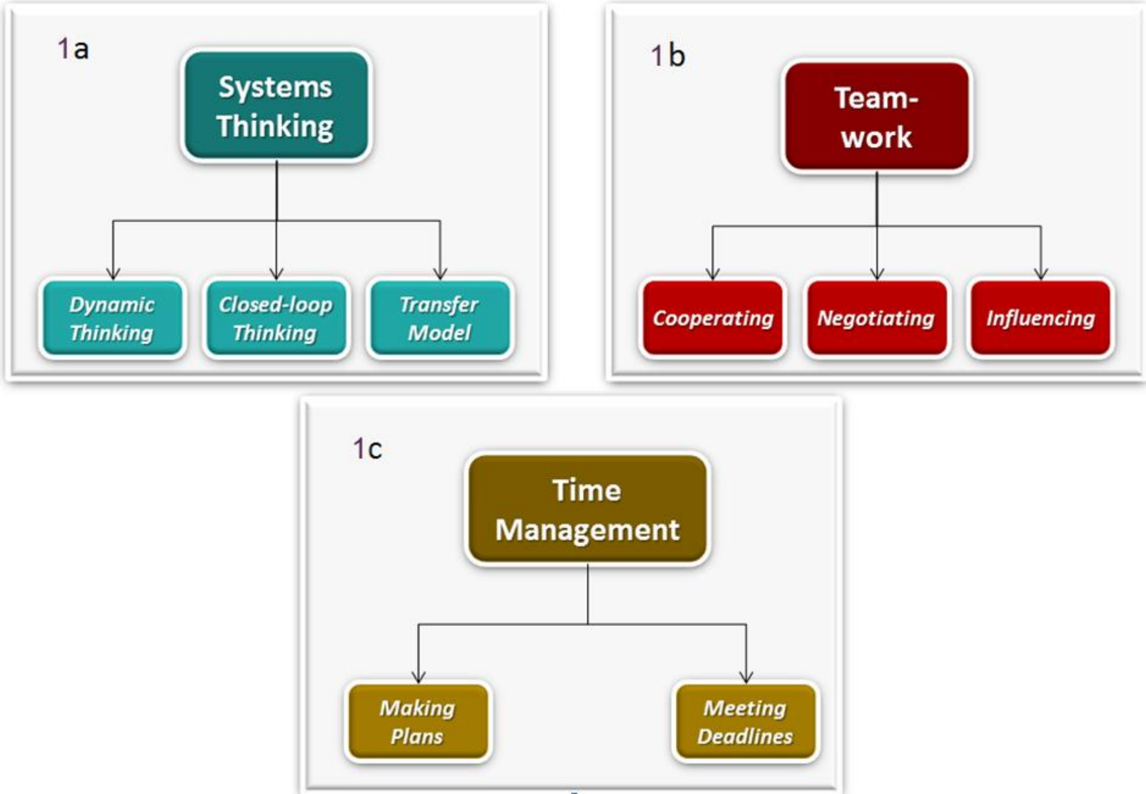

Figure 1 Three competency models for student assessment at Q2L

The first research question that we addressed related to student assessment was: *Does the incoming cohort of 6th grade students at Q2L demonstrate improved performance over 20 months in the areas of systems thinking, teamwork, and time management skills?* These three competencies are supported (albeit implicitly) during the course of daily school activities (e.g., completing projects in small groups, designing games).

In addition, we examined this cohort's academic achievement (i.e., mathematics and reading skills) in relation to New York state standardized tests. Thus the second research question is: *Do the three focal competencies predict academic achievement relative to the state mandated math and reading test scores?* We tested whether Q2L is successfully supporting students' development of important new competencies as a function of its unique environment, while not sacrificing traditional (i.e., math and reading) academic achievements.

In relation to our first research question, we hypothesized that students will, on average, demonstrate improved performance in relation to the three focal competencies from the initial (Time 1, September 2009) to the final (Time 4, May 2011) assessment. In terms of research question 2, we hypothesized that there will be significant relationships among our three competencies and the annual standardized state test scores, despite the fact that there are no explicit math and reading courses at Q2L. Rather, the courses are interdisciplinary in nature—where math and reading skills, along with systems thinking and design thinking skills are exercised in various courses like Code Worlds and The Way Things Work.

As noted earlier, we used existing instruments to assess our three focal competencies during this research project. The systems thinking competency was assessed using a modified version of the protocol described in Torres' recent (2009) dissertation on the topic, which in turn was based on the protocol described in Sweeney and Sterman (2007). There are 12 constructed-response items in this assessment, with different examples of systems used across administrations (e.g., hunger/eating vs. predator/prey relations). Appendix 1 includes the full set of questions used in the ST assessment.

Teamwork and time management skills were measured via instruments that have been designed, developed, and validated by the Educational Testing Service for use by middle school students (see, for example, MacCann, Duckworth, and Roberts 2009; Wang, MacCann, Zhuang, Liu, and Roberts 2009; Zhuang, MacCann, Wang, Liu, and

Roberts 2008). The first teamwork assessment contained 57 Likert-scale items and 12 scenario-based items, but subsequent administrations of the assessment used fewer items (i.e., 22 Likert-scale items that had the strongest weights on the three focal factors—cooperating, negotiating, and influencing others, along with 12 scenario-based items). The first time management assessment contained 36 Likert-scale items, and subsequent administrations employed only 24 items (again, those weighting most strongly on the focal two factors—making plans and meeting deadlines). The items comprising the assessments for both the teamwork and time management skills are presented in Appendices 2 and 3.

Example items (with text boxes for entering constructed responses) from the systems thinking protocol include: How are hunger and eating related or connected to each other? If you just finished eating, what happens to your level of hunger over time? Can you think of another situation that feels or seems like the same as this? Rubrics have been adapted from Torres' (2009) and Sweeney and Sterman's (2007) research to score the responses. For instance, there are five levels for the systems thinking rubric (from 0 to 4). Each level contains a description as well as multiple examples of student responses for each of the three main variables: dynamic thinking, closed-loop thinking, and transfer of models (i.e., Level 0: Incorrect or non-applicable response; Level 1: Describes static interconnections; Level 2: Describes aspects of system structures and behaviors; Level 3: Demonstrates understanding of principles guiding system behaviors (though descriptions may be limited); and Level 4: Full utilization of systems intelligence, such as a description of a system at multiple levels). See Table 2 for the five scoring levels across the three main facets of ST.

Table 2 Systems Thinking Scoring Rubric (adapted from Sweeney and Sterman, 2007)

	Dynamic Thinking Level A: Identification of system elements and interrelations Level B: Specify variables and problems	**Closed-loop Thinking** Level A: Understanding of basic system concepts Level B: Elaborate causal reasoning	**Transfer the Model** Identification of similarities across systems
***Level 0*:** *Incorrect or non-applicable response*	There is no response, response of "I don't know", or non-applicable response.	There is no response, response of "I don't know", or non-applicable response.	There is no response, response of "I don't know", or non-applicable response.
***Level 1*:** *Describes static interconnections*	Includes identification of <u>some</u> discrete elements within a system. Interconnections and inter-relationships are described in <u>linear and/or static</u> (vs. dynamic) terms.	Includes a description of interconnections and inter-relationships in linear and/or static (vs. in closed loop) terms.	Involves an attempt to indicate a similar structure.
***Level 2*:** *Describes aspects of system structures and behaviors.*	Shows <u>some</u> identification of discreet elements within a system, understanding of the attributes and characteristics of elements within a system, including a dynamic or an interconnection.	Shows <u>some</u> understanding of the behaviors and characteristics of reinforcing <u>and/or</u> balancing feedback loops, including looped interconnections, time delays, and feedback types.	Shows <u>some</u> understanding of the similarities and differences between natural, technological or social systems.

***Level 3*:** *Demonstrates understanding of principles guiding system behaviors (though descriptions may be limited).*	Demonstrates sound understanding of discreet elements within a system, understanding of the attributes and characteristics of elements within a system, including a dynamic or an interconnection.	Demonstrates sound understanding of the behaviors and characteristics of reinforcing and/or balancing feedback loops, including looped interconnections, time delays, and feedback types.	Demonstrates sound understanding of the similarities and differences between natural, technological or social systems.
Level 4*:** *Full utilization of systems intelligence, such as a* ***description *of a system at multiple levels*	Includes a full manifestation of understanding of discreet elements within a system, understanding of the behaviors and characteristics of elements within a system, including multiple dynamic interconnections at multiples levels.	Includes a full manifestation of systemic reasoning including understanding of the behaviors and characteristics of reinforcing and/or balancing feedback loops, and a description of looped interconnections, time delays, and feedback types.	Includes a clear understanding of the similarities and differences between natural, technological or social systems and includes clear and novel observations and descriptions of similar structures.

Example items from the teamwork survey (with 5-point Likert-scale responses, from never to always) are: I don't have an opinion until all of the facts are known; I know how to make other students see things my way; I give in when arguing; and I find it difficult to keep team members on task. Finally, some items from the time management survey (similarly on a 5-point Likert scale, from never to always) include: I complete my homework on time; I put off tasks until the last minute; I keep my desk neat; and I like routine. Prior to data analysis, some items were reverse coded so that all items would be in the same direction (i.e., higher values = more often or more positive).

The student assessments occurred at approximately six-month intervals[i], including the initial and final weeks of this 20-month period, yielding four different data collection times (i.e., September 2009, March 2010, November 2010, and May 2011). This enabled us to capture the current levels of the competencies, and monitor their development over time. The systems thinking assessment took approximately 45 minutes while teamwork and time management took around 25 minutes each to complete. All were administered during non-academic periods, and staggered across two days (i.e., ST on one day and TW and TM on the next) to attenuate fatigue. The first administration of each of our three assessment instruments was delivered in paper and pencil format. The three remaining administrations were delivered online, where students simply clicked on a link that took them directly to the assessment. Earlier analyses revealed no differences in terms of delivery mode (see Shute and Torres, 2012).

Traditional achievement testing occurred as part of normal New York state requirements for sixth-grade students. This took place at the end of the school year (i.e., June 2010).

Method

Sample

The primary sample we studied at Q2L consisted of 70 students (42 male, 28 female) who began the study in 2009 in the sixth grade and concluded at the end of the seventh grade. They were assessed at four different time periods. We also tested students who began in the fall of 2010 as new sixth graders (n = 76). This second cohort of students was only assessed at two time periods.

Among the students at the school, about 40% received free or reduced lunch, and 60% paid for lunch in full. The ethnicity composition of the students is approximately 34% Caucasian, 32% African-American, 29% Hispanic, and 5% Asian.

Reliability

Before analyzing student performance on our set of assessments, we first needed to establish that the instruments we employed were, in fact, sound (i.e., reliable and valid). Because the systems thinking assessment was the only one involving constructed responses, we additionally needed to determine the inter-rater reliability of the scores.

Inter-rater Reliability of Systems Thinking Scores. To score the responses on the ST assessment, we used two separate teams of scorers, with two persons per team. Scoring in the first administration (Time 1) was accomplished by the two teams independently scoring all students' constructed responses using our 5-point (levels 0-4) rubric. Both teams (a) recorded their scores in an Excel spreadsheet, then (b) exchanged spreadsheets with the other team, and (c) highlighted scores that differed by > 2 points. The highlighted scores were then discussed and re-scored; in some cases converging on the same number, and in other cases changing to scores that differed by only one point. In the first administration of the ST assessment, this exchange-discuss-revise process required two full iterations until no scores were > 1 point different. By the time of the second, third, and fourth administrations, using the same teams, just one iteration was required, with only a few discrepant scores requiring discussion. The inter-rater reliabilities of the scores on the ST assessment were: Time 1, Spearman's rho = .87, and for Time 2, Spearman's rho = .96. Subsequent administrations, using the same two-team process, showed similarly high inter-rater reliabilities (i.e., in the mid-90s).

Internal Reliability. The alpha reliabilities of the three assessments were calculated across all four administrations and were judged to be appropriate. See Table 3 for Cronbach alpha reliabilities for each of the three assessments across the four time periods.

Table 3 Reliabilities (and sample sizes) for assessments across four time periods

Competency	Time 1	Time 2	Time 3	Time 4
Systems Thinking	.82 (*n*=70)	.85 (*n*=66)	.80 (*n*=41)	.84 (*n*=43)
Teamwork	.84 (*n*=63)	.82 (*n*=59)	.88 (*n*=49)	.86 (*n*=53)
Time Management	.81 (*n*=69)	.83 (*n*=62)	.84 (*n*=59)	.84 (*n*=54)

Next, we examine learning or growth over time in relation to our three competencies.

Results

Table 4 displays the overall means (and standard deviations) of the three competencies over the four time points.

Table 4 Focal Competency Means, SDs and Statistics for the Four Administrations

	Time 1	Time 2	Time 3	Time 4	*n*	*F*
Systems Thinking	0.90 (.42)	1.20 (.53)	0.95 (.48)	1.13 (.62)	26	2.07
Teamwork	3.49 (.45)	3.40 (.41)	3.60 (.45)	3.51 (.29)	33	1.03
Time Management	3.65 (.52)	3.57 (.49)	3.55 (.50)	3.65 (.45)	35	0.01

We computed a repeated measure ANOVA using Time 1, Time 2, Time 3, and Time 4 as the repeated measures. As can be seen, there were no significant differences among the means across all four time points. However, note that the means in Table 4 represent students who participated in *all four* administrations. That is, if a student missed even one administration (e.g., completed assessments at Times 1, 3, and 4, but was absent at Time 2) her data (from all four times) were removed from the analysis given our repeated-measures design. In addition, note that data collection with middle school students can be difficult. Assessments were given in the classroom, where students were sitting adjacent to one another. This can (and did) create distractions to students who were trying to take the assessment seriously. Thus we felt that a better analysis was to take the first and fourth administrations and run a separate analysis to see if there were any significant changes to mean scores.

This simplified analysis also serves to increase the sample size (compared to the data in Table 4) as it includes students who only had to participate in the first and fourth administrations. To illustrate, for ST, the sample size of students who participated in all four administrations (shown in Table 4) was $n = 26$ compared to those who completed the Time 1 and Time 4 ST assessments shown in Table 5 ($n = 35$). Table 5 displays the means of the three competencies for students who took the assessments at Time 1 and Time 4.

As can be seen, the results show a significant improvement from Time 1 to Time 4 for ST. There are no significant improvements, however, for teamwork and time management.

Table 5 Competency Means, SDs and Statistics for the First and Fourth Administration

	Time 1	**Time 4**	***n***	***t***
Systems Thinking	0.95 (.43)	1.21 (.57)	35	3.72**
Teamwork	3.46 (.46)	3.53 (.33)	42	0.97
Time Management	3.55 (.55)	3.59 (.49)	46	0.72

** p <.01

The next section reviews each competency in relation to the first and fourth administrations at the facet level.

Systems thinking (ST)

As shown in Table 5, students who were currently in (and finishing) the 7th grade (i.e., those who started at Q2L as sixth-graders when it opened in September 2009) significantly improved on their overall ST skills from Time 1 to Time 4 (t (34) = 3.72; p < .001). When the three ST facets were analyzed separately (see Figure 1a), we found significant gains for two of them—dynamic thinking and transfer the model (as well as a non-significant gain for closed-loop thinking). The second cohort of students (i.e., starting 6th grade the following academic year—September 2010) also showed significant gains on their ST skills from Time 1 (M = .58; SD = .24) to Time 2 (M = .88; SD = .36); (t (21) = 4.20; p < .001).

To illustrate growth in ST skills, here are the responses by a Q2L student at Time 1 and Time 4 for two ST questions: (a) What is an example of a system? and (b) Identify at least two parts of your system and explain how they relate to each other. At Time 1 she responded: (a) An example is a puzzle; (b) I don't know. At Time 4 her responses were more meaningful: (a) The transportation or subway system is an example of a system; (b) Two parts of the transportation system are the people and the metrocards. They relate to each other because the system wouldn't work if people didn't buy metrocards to use for the trains. If there were no metrocards, people wouldn’t be able to go on the trains and buses, and the government would not be able to make a profit.

Table 6 displays the relationship among ST scores across the four time points, which shows that the test-retest reliability of ST is consistent over the four time points.

Table 6 Correlations among ST Measures across the Four Time Points

	ST2	**ST3**	**ST4**
ST1	0.51**	0.55**	0.69**
ST2		0.37*	0.57**
ST3			0.74**

* $p < .05$; ** $p < .01$

Teamwork (TW)

While students showed higher Time 4 than Time 1 scores on their overall teamwork scores, the difference was not significant. However one of the facets of TW (i.e., influencing others) did show a statistically significant increase over time (t (41) = 5.13; $p < .001$). The 6th graders did not show significant gains on TW—either overall or by factors. Table 7 displays the relationship among TW across the four time points. These correlations show that the test-retest reliability of TW is consistent over the four time points.

Table 7 Correlations among TW Measures across the Four Time Points

	TW2	TW3	TW4
TW1	0.53**	0.47*	0.43*
TW2		0.70**	0.55**
TW3			0.57**

* $p < .05$; ** $p < .01$

Time management (TM)

Similar to the findings of TW over time, students did show a small improvement on their overall TM scores from Time 1 to Time 4, but this was not statistically significant. However, one of the TM facets (meeting deadlines) did show a significant gain (t (45) = 2.18; $p < .05$). The 6th graders did not show significant gains on TM—either overall or by factors. Table 8 displays the relationship among TM across the four time points. Again, this illustrates that the test-retest reliability of TM is consistent over time.

Table 8 Correlations among TM Measures across Four Time Points

	TM2	TM3	TM4
TM1	0.68**	0.34*	0.59**
TM2		0.66**	0.63**
TM3			0.74**

* $p < .05$; ** $p < .01$

Relationships among the three competencies

Table 9 displays the relationships among the three competencies at Time 4. As can be seen, there is no significant relationship between ST and either TW or TM. There is, however, a moderate relationship between TM and TW. This is important since it shows that the three assessments are not measuring the same competencies. That is, if the correlation between TW and TM was .70 or higher (which it was not), we would suspect they were measuring the same construct. Also, because both TW and TM were assessed via the same method (i.e., self-report, with five-point Likert scale), we would expect some degree of overlap given that they share method variance.

The next section shows how these variables uniquely predict state test scores.

Table 9 Correlations among Competencies at Time 4

	TM	**TW**
ST	0.30	0.15
TM		0.54**

* $p < .05$; ** $p < .01$

Predictive Validity

We found that the scores from the last administration of the three competency assessments correlated with state test scores. ST significantly correlated with math ($r = .44$, $p < .01$) and reading ($r = .41$, $p < .01$) test scores; TW only significantly correlated with math ($r = .29$, $p < .05$) and not reading; and TM marginally correlated with reading ($r = .27$, $p = .05$), but not with math. Scores came from the final (Time 4) assessments. This suggests that the competencies are positively associated with state test scores.

To examine the incremental validity of the three competencies on state standardized math and reading scores, we then conducted two hierarchical regression analyses. In the first, we predicted math score from ST, TW, and TM (see Table 10). We chose to enter ST first in both analyses given that it was a more cognitive measure than either TW or TM.

Table 10 Hierarchical regression analysis with competencies and math

Model	**R-Square**	**F Change**
1--ST	.219	9.80**
2--ST, TW	.235	0.74
3--ST, TW, TM	.236	0.03

** $p < .01$

Table 11 shows the results from our hierarchical regression analysis predicting reading test score.

Table 11 Hierarchical regression analysis with competencies and reading

Model	**R-Square**	**F Change**
1--ST	.163	7.21*
2--ST, TW	.194	1.36
3--ST, TW, TM	.238	2.02

* $p < .05$

Results from both regression analyses indicate that ST significantly predicts both math (22% unique variance) and reading (16% unique variance) standardized test scores while our other two competencies (TW and TM) do not appear to predict any unique variance of the state test scores. This suggests that (a) ST is an important skill to continue to support as it positively predicts state test scores, and (b) while TW and TM may indeed not predict state test scores, we may still want to explore alternative methods of assessment for TW and TM, which we will describe further in the discussion section.

Gender and Socio-Economic Status (SES)

Although the sample size is small, we conducted an exploratory examination of the effects of gender and SES in relation to ST growth. First, we examined students' scores for ST at Time 1 vs. Time 4, separately by boys (*n* = 21) and girls (*n* = 16) in our sample. We computed a repeated measures ANOVA (ST Time 1 and Time 4) with gender as the between-subjects variable. The main effect was significant (F (1, 35) = 10.42; p = .003) and the interaction with gender was also significant (F (1, 35) = 5.99; p = .02). A graph of the interaction is shown in Figure 2. Further analysis showed that the boys significantly improved over time relative to ST more than the girls (t (20) = 4.10; p = .001.

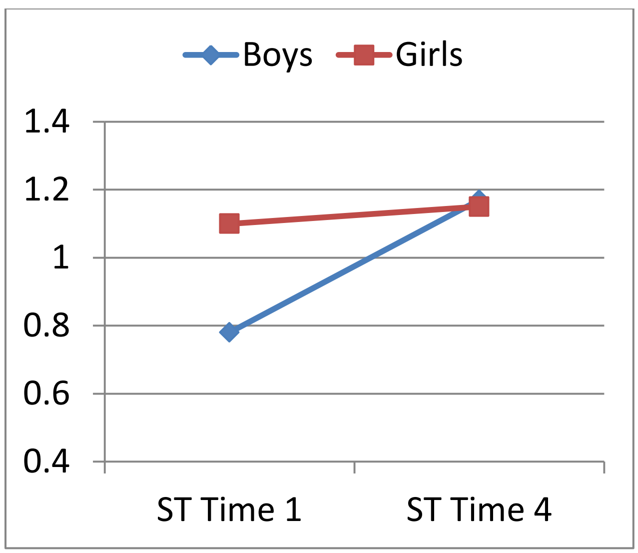

Figure 2 Interaction among ST (Time 1 vs. Time 4) and gender

We similarly evaluated gender and our other two competencies (i.e., TW and TM), but found no interactions.

Our SES variable was coded relative to whether students at Q2L received a free or reduced lunch, or not. We again computed a repeated measures ANOVA for our three competencies (at Time 1 vs. Time 4) with SES as the between-subjects variable. For each of the three competencies, no interactions involving SES were found. This may be viewed positively as students, regardless of SES, appear to be improving equally on ST.

Discussion

This research attempted to answer preliminary questions regarding the effectiveness of Q2L, particularly in relation to supporting important 21st century competencies. We hypothesized that students would demonstrate improved performance in relation to the three focal competencies from initial (Time 1, September 2009) to final (Time 4, May 2011) assessment. We found partial support for this hypothesis in that ST did improve significantly when comparing the data from Time 1 and Time 4. While we did not find growth in TW and TM from Time 1 to Time 4, this may be attributed to the method (i.e., self-report) by which we chose to assess TW and TM. Moreover, self-report measures are easy to administer, but they are not typically used to measure growth over time. Additionally, self-report measures are susceptible to social desirability effects which can affect the validity of the assessment. Using more performance-based methods (e.g., classroom observation) to assess TM and TM in Q2L might yield more favorable results.

While the results of this formative evaluation are interesting—particularly regarding the improvement for systems thinking skill from Time 1 to Time 4—more research is needed to understand fully how (and why) Q2L impacts students. Given the relatively small sample size, it was difficult to measure the growth of competencies unequivocally. In the future, larger samples of students will enable researchers to see how certain characteristics and demographics of the students (e.g., gender, SES) as well as context play a role in how Q2L impacts students. For example, how do girls versus boys grow in important competencies in Q2L over time? Does Q2L help to reduce the achievement gap among different SES brackets or ethnicities? What are the best settings at Q2L to foster better thinking (and behaving) skills?

Given the current design, we do not know conclusively if students' gains are simply a function of normal cognitive development or are, in fact, a function of being part of Q2L. Furthermore, the current research did not include a control group in the analysis of competency growth. However, given that students at Q2L did demonstrate significant improvements in ST skill across the 20-month period, and ST is a difficult skill to master (even for adults), we suspect that the ST growth was primarily a function of being part of Q2L.

Looking forward, while the assessments that we used in this study were adequate for the exploratory nature of this research, they are not optimal for large-scale, meaningful evaluations within Q2L and across multiple schools—especially for the TW and TM competencies. Future research should focus on using more performance-based assessments across a range of competencies that are of value to Q2L.

Finally, this evaluation research should be viewed as a preliminary probe into the opportunities and challenges encountered in the process of translating a new, innovative model of schooling into practice. As such, we have only analyzed the tip of the proverbial iceberg which is the Q2L model with its many dynamic and interrelated parts (e.g., interdisciplinary curriculum, immersive environment, challenge-based learning experiences). And as with any bold new idea, the success of its implementation won't be known for years, and certainly not after just 20 months.

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Notes

Our third administration (i.e., November, 2010) was delayed for two months as Q2L physically moved its location over the summer and was still in the process of setting up the technical infrastructure in September and October 2010, thus delaying the third assessment session.

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Appendix 1—Systems Thinking Assessment Questions

Directions

Below you will find 12 questions that you should read and respond to. Please answer *all* questions. Don't spend too much time deciding on what your answer should be. There are no right or wrong answers.

SYSTEMS

1. *What does the word "system" mean to you?*

2. *What is an example of a system?*

3. *Identify at least two parts of the system and explain how they relate to each other.*

TIREDNESS AND SLEEP

Think about the relationship between tiredness and the number of hours slept.

4. *How are tiredness and amount of sleep related or connected to each other?*

5. *If you sleep less, what happens to your level of tiredness over time?*

6. *Can you think of a different situation that feels the same as this?*

SILLY BANDZ

7. *You and your best friend Margot have been collecting silly bandz for a year. You often argue about who has more. You definitely want to have more silly bandz than Margot because you don't want her to brag about it. Think about the relationship(s) among: (a) the number of silly bandz you have, (b) the level of competition between you and Margot, and (c) your motivation to buy more silly bandz. How might these three be interrelated? What do you think happens to your motivation to buy more silly bandz and the number of silly bandz you have over time?*

8. *If you have more silly bandz, what happens to the level of competition between you and Margot and your motivation to buy more silly bandz?*

9. *Can you think of a different situation that feels the same as this?*

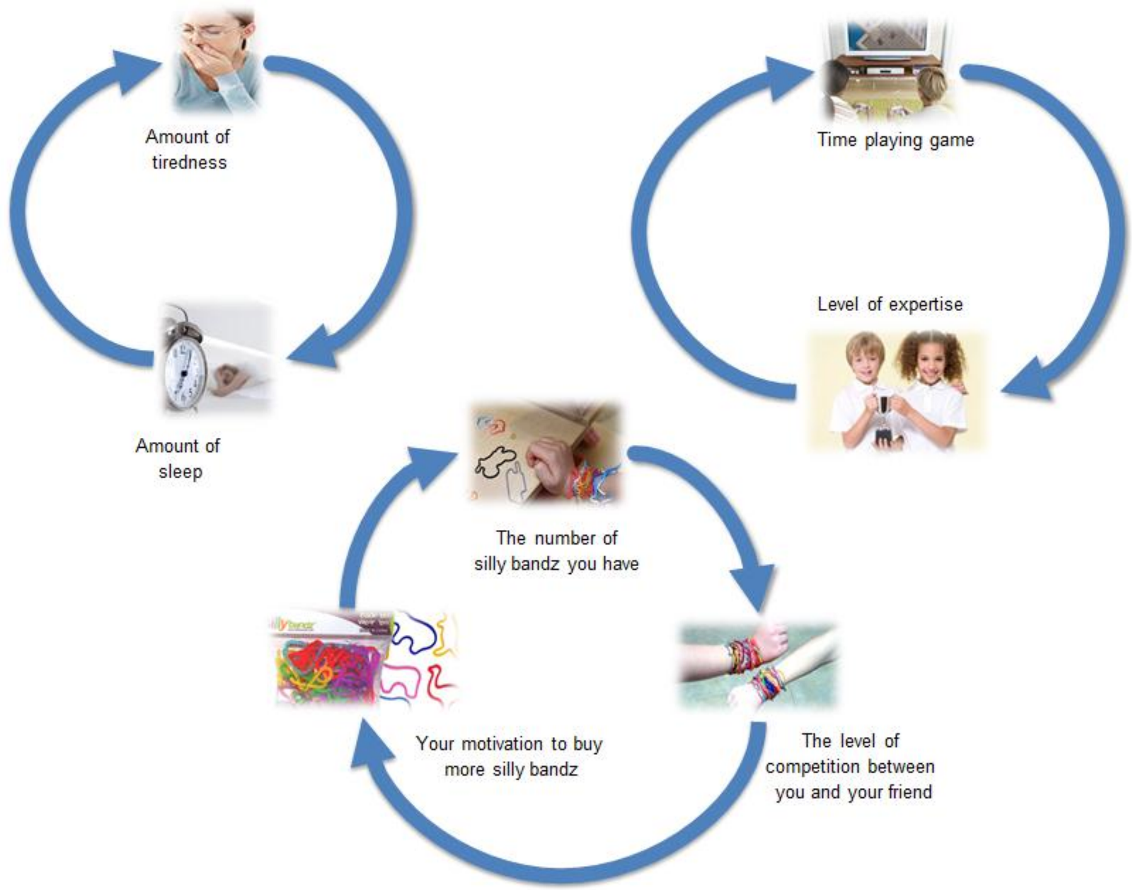
PLAYING GAMES

10. *How does the amount time spent playing your favorite game affect your expertise in playing the game? What do you think happens to these two things over time?*

11. *Can you think of a different situation that feels the same as this?*

CYCLES

12. *Take a look at the image below with the three cycles (tiredness, games, and silly bandz). Which two do you think are similar and why?*


Amount of tiredness
Amount of sleep
Time playing game
Level of expertise
The number of silly bandz you have
The level of competition between you and your friend
Your motivation to buy more silly bandz

Appendix 2—Teamwork Survey

Section 1: Thinking, Feeling, and Acting

Directions

Below you'll find 22 statements about how you behave when you are in team situations or during group projects. You should read and decide how well each one of them describes the way you think or feel in these situations. For each item, please choose one of the 5 options ranging from "never" to "always." Please reply to all statements. Don't spend too long deciding what your answer should be. Answer all statements even if you're not entirely sure of your answer. There are no right or wrong answers. SELECT THE CIRCLE FOR EACH ITEM THAT MATCHES YOUR BEST RESPONSE.

1. *I don't have an opinion until all of the facts are known*.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

2. I know how to make other students see things my way.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

3. I am flexible when doing group projects.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

4. I dislike being in a position of responsibility for other people.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

5. I like to be in charge of group projects.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

6. I enjoy helping team members.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

7. I prefer working alone over working with others.

Never	Rarely	Sometimes	Often	Always

❍ ❍ ❍ ❍ ❍

8. I can make deals in any situation.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

9. Feedback is important to me.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

10. I like to solve problems using different tactics.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

11. During group assignments, I make demands on other students.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

12. I suggest different solutions to problems.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

13. I find it difficult to approach classmates.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

14. I enjoy bringing team members together.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

15. I believe that I’m a good leader.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

16. I can convince my peers about anything.

Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always ❍

17. I can fight for a cause that I believe in.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

18. I know when to step in when an argument starts getting out of control.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

19. I'm influenced by other students' opinions.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

20. I learn from other students.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

21. I think that trading ideas among students leads to the best solutions.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

22. I am inspired by others' ideas and thoughts.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

Section 2: Scenarios (Optional)

Directions

In this section, you'll find a number of paragraphs describing various situations (scenarios). You need to evaluate how effective you think several reactions to the situation are. Please read each scenario carefully before choosing your response. Don't spend too long deciding on each answer. Please answer all of the statements even if you're not entirely sure of your answer. There are no right or wrong answers.

SCENARIO 1: *You're part of a study group that has been assigned a large presentation for class. As you are all dividing up the work, it becomes clear that both you and another team member are interested in researching the same aspect of the topic. Your friend already knows a lot about the area, but you have been extremely excited about working on this part of the assignment ever since your teacher mentioned it.*

1. Flip a coin to determine who gets to work on this part of the assignment.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

2. Insist that, for the good of the group, you should work on this part of the assignment because your interest in the area means you will do a really good job.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

3. Forget all about your interest and allow your friend to work on this aspect of the assignment.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

4. Suggest to the other group member that you both share the research for this aspect of the assignment. You can then also share the research on another less desirable part.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

SCENARIO 2: *Imagine that your teacher has assigned each person in the class to a small group to work on a problem. After breaking into small groups to discuss the problem, everyone gets back together in class to go over the ideas generated in each small group. When it's your group's turn, the person who volunteered to serve as spokesperson begins to present his or her own ideas, some of which had not been discussed in the small group, rather than the ideas generated in the group discussion.*

1. Do nothing in order to preserve the impression that your group worked well together.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

2. Challenge the spokesperson, because it's important that only the ideas agreed upon by your group be presented.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

3. Keep silent during class, but afterwards speak with the instructor privately about the spokesperson.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

4. Politely add additional comments, making sure that the ideas the group discussed are presented.

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

SCENARIO 3: *You've decided to set up a new web site about your school—from the perspective of students. You've been given permission and a deadline: three weeks to complete it. Nine other students have signed up to help you. At your first meeting, you want to assign jobs for everyone, such as creating the graphics (2D and 3D), animations, code, content, online surveys/polls, and so on. But how will you assign each person to the tasks?*

1. *Ask each student which job they would like and then resolve any conflicts based on who asked first.*

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

2. *Ask each team member which job they would like to take on, and then resolve any conflicts by drawing names out of a hat.*

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

3. *Make a list of the team members' strengths and preferences and assign jobs that match their strengths most closely.*

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

4. *Assign the best jobs to your friends first, and then give the remaining jobs to the rest of the team members randomly.*

Very Ineffective	Ineffective	Neutral	Effective	Very Effective
❍	❍	❍	❍	❍

Appendix 3—Time Management Survey

Directions

Below you will find a number of statements that you should read and decide how well each one of them describes the way you think or feel. *Please reply to all statements*. Give your first impression of whether each statement describes the way you think and feel about it. Don't spend too long on deciding what your answer should be. Answer all statements even if you're not entirely sure of your answer. There are no right or wrong answers. SELECT THE CIRCLE FOR EACH ITEM THAT MATCHES YOUR BEST RESPONSE.

1. I complete my homework on time.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

2. I never put off tasks until the last minute.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

3. When I have to be somewhere, I arrive on time.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

4. I keep my desk neat.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

5. *I like routine.*

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

6. *I am never (or rarely) late for class.*

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

7. I like to make schedules.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

8. I write tasks down so I won't forget to do them.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

9. When I am going somewhere, I am never late.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

10. I use computers or cell phones to remind me of deadlines.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

11. I know what is in my backpack.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

12. Each day, I spend a few minutes planning what I am going to do tomorrow.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

13. I mark dates that are important to me on a calendar.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

14. People never complain that I am late.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

15. I like to make lists of things to do.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

16. My teachers are glad that I'm never late for class.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

17. I keep my locker neat.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

18. I'm rarely late for breakfast.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

19. I finish tests with plenty of time to go over my answers.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

20. I plan events ahead of time with my friends.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

21. I have already planned all the things I am going to do tomorrow.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

22. I am early for practice (sports, music) or anything I might do after school.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

23. I am one of the first people to get to class.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍

24. I know what I want to do next weekend.

Never	Rarely	Sometimes	Often	Always
❍	❍	❍	❍	❍