A Return to "A Complexity Context to Classroom Interactions and Climate Impact on Achievement"

Joseph Cochran

The College at Brockport, State University of New York

Liz Johnson

*The University of North Carolina Charlotte
& Complex Systems Institute*

Abstract

When JPCS published "A Complexity Context to Classroom Interactions and Climate Impact on Achievement" in 2017, the article was a cutting-edge application of ABM to classroom dynamics. Five years later, though, there have been dramatic changes to education as a result of the COVID-19 pandemic. While the technology of ABM has advanced sufficiently that reexamining of the topic may be justified, the trauma caused by the pandemic should make us question whether any such model would accurately reflect the real world. Given the isolating nature of COVID-19 and online learning, the purpose of this article is to remind us that in a classroom environment, "every interaction matters." Effective action steps can easily be taken to dramatically strengthen interactions and thus strengthen leaning networks, which will lead to higher levels of achievement. This can be done by the means of simple strategies like increasing positive climate behavioral markers in the classroom, like using student names, checking-in with students, smiling, using polite language, laughing, and clapping. In contrast, negative behavior markers like anger, sarcasm, irritability, harsh voice, yelling, exclusion of students, bad language, physical control of students, teasing, and bullying must be eradicated.

Keywords: complexity, classroom environment, interactions, networks, COVID-19, dragon kings

Un regreso a "Un contexto de complejidad para las interacciones en el aula y el impacto climático en el rendimiento"

Resumen

Cuando JPCS publicó "Un contexto de complejidad para las interacciones en el aula y el impacto climático en el rendimiento" en 2017, el artículo fue una aplicación de vanguardia de ABM a la dinámica del aula. Sin embargo, cinco años después, ha habido cambios dramáticos en la educación como resultado de la pandemia de COVID-19. Si bien la tecnología de ABM ha avanzado lo suficiente como para que se justifique reexaminar el tema, el trauma causado por la pandemia debería hacernos cuestionar si algún modelo de este tipo reflejaría con precisión el mundo real. Dada la naturaleza aislante del COVID-19 y el aprendizaje en línea, el propósito de este artículo es recordarnos que en el ambiente de un salón de clases, "todas las interacciones son importantes". Se pueden tomar fácilmente pasos de acción efectivos para fortalecer dramáticamente las interacciones y, por lo tanto, fortalecer las redes de aprendizaje, lo que conducirá a niveles más altos de logro. Esto se puede hacer por medio de estrategias simples como aumentar los marcadores de comportamiento de clima positivo en el aula como: usar los nombres de los estudiantes, registrarse con los estudiantes, sonreír, usar un lenguaje cortés, reír y aplaudir. Por el contrario, se deben erradicar los marcadores de comportamiento negativo como la ira, el sarcasmo, la irritabilidad, la voz áspera, los gritos, la exclusión de los estudiantes, el lenguaje soez, el control físico de los estudiantes, las burlas y el acoso.

Palabras clave: complejidad, ambiente de aula, interacciones, redes, COVID-19

重审《复杂情境：课堂互动和课堂气氛对成绩产生的影响》

摘要

当《政策与复杂系统杂志》于2017年发表《复杂情境：课堂互动和课堂气氛对成绩产生的影响》一文时，该文是基于Agent模型（ABM）应用于课堂动态的最新案例。5年后，因

2019冠状病毒病（COVID-19）大流行的影响，教育发生了显著变革。尽管ABM技术已有了充足的进步，让对该主题进行再分析一事具备合理性，但大流行造成的创伤让我们质疑这类模型是否能精确反映现实世界。鉴于COVID-19和网络学习的孤立性质，本文旨在提醒我们，在课堂环境中，"一切互动都至关重要"。（教师）能轻松采取有效的行动步骤，以显著加强互动，并因此增强学习网络，进而将导致更高的学习成绩。此举能通过一系列简单策略完成，例如增加积极的课堂气氛行为标记，包括使用学生姓名、问候学生、微笑、使用礼貌语言、大笑、以及鼓掌。相反，消极的行为标记，例如愤怒、讥讽、易怒、厉声、吼叫、排斥学生、不良语言、对学生进行身体控制、嘲笑和霸凌等行为必须被消除

关键词：复杂性，课堂环境，互动，网络，2019冠状病毒病

Introduction

Within the complexity science literature, there is the concept of the Dragon King (See Figure 1), which is a massive event that comes from unique origins (Ricci & Sheng, 2017). The size of Dragon Kings makes them 'kings' while their uniqueness makes them 'dragons.' They arise from wickedly complex feedback loops that align to multiply the impact of the events that feed the developing Dragon King. When Dragon Kings are finally 'born,' the largest can change the course of human history through the devastation that they cause, though smaller Dragon Kings exist.

The COVID-19 pandemic is among the largest Dragon Kings in recent history because of its economic and social impact. Its economic impact is at least $10 trillion, though it will likely be decades before its true economic consequences can be determined. Its social impact is equally large because it is the fifth most deadly pandemic in human history, having possibly killed over twenty million people globally. Within the USA, it is the single largest mass casualty event in American history, as its nearly one million fatalities exceed the death tolls of any other mass casualty event in US history.

We would consider the COVID-19 pandemic a Dragon King because it benefited from a unique combination of factors that allowed it to be the first global pandemic of the 21st century. It benefited from the fact that it arose in Wuhan during late 2019, when the local officials were unwilling to take steps to deal with a potential pandemic because of political reasons. It benefited from a global trade network more extensive than any that had existed in the 20th century, which allowed it to spread

quickly throughout the world. It benefited from the fact that conservatives in the American and European continents were unwilling to initially quarantine their populations due to concerns about the impact on their national economies. Finally, it benefitted from a massive amount of disinformation and misinformation spread through social media.
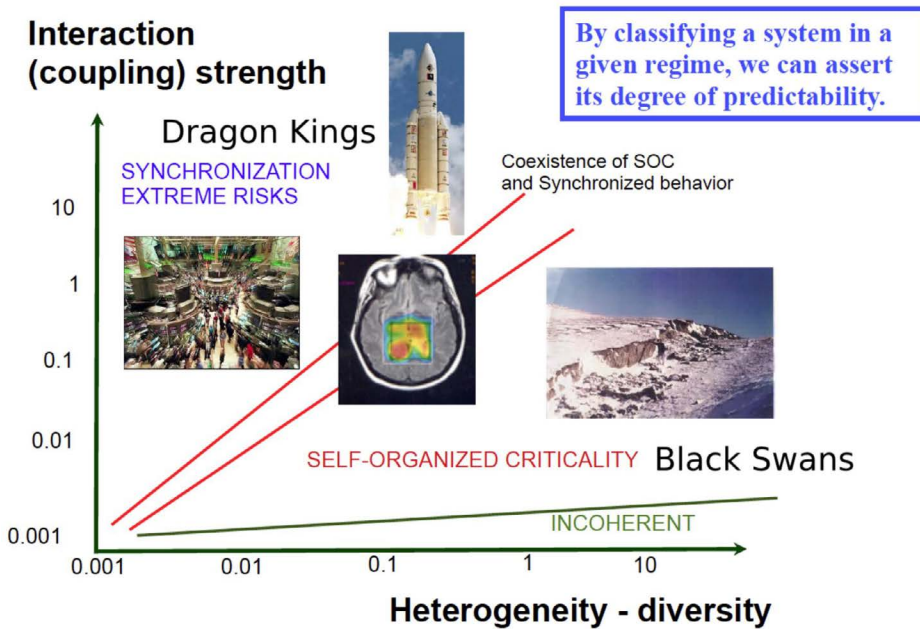

Figure 1. Predictability based on interaction and diversity in a system (Sornette, 2009).

Education

When it came to education, the COVID-19 pandemic resulted in challenges that administrators, parents, students, and teachers were not prepared to meet. Within the USA, the entire education system shifted from primarily in-person to exclusively virtual in just a couple of months, disrupting the education of students and destroying the engagement that they had developed within the classroom. Suddenly, students were physically disengaged from their peers and their teachers, which had dramatic consequences on their educational performance and their psychological well-being.

No published study could have predicted the impact of the pandemic because no journal would have published such an exploration. Before COVID-19, the only successful pandemic in the last half century had been the HIV/AIDS pandemic, which had only been able to spread and survive because it did not cause visible symptoms during the first couple of years

of infection, allowing an infected person to spread it to other people before they started to show symptoms of the sickness. Pandemics of the type that COVID-19 represented had been defeated by modern medicine, so they were not worth modeling, especially when it came to the field of education.

The previous three years have shown us the error of our arrogance, that technology can just as effectively spread a pandemic as it can prevent it, especially when people do not care about the consequences of their decisions and/or lack an understanding of basic science. When workers are unwilling to wear masks or to accept vaccination when they know that they will face termination of employment, it suggests that society has failed on some fundamental level. The only question becomes the source of the failure.

Since the pandemic occurred, though, there is an opportunity for researchers to not only model rare events, but to also model failures of society. The pandemic revealed massive failures within American society, primarily related to decades of reduced taxation for the middle and upper classes, decades of reduced services for the working and lower classes, and decades of worship for the corporation. The American education system suffers from each of these failures, as conservative governments have reduced funding for public schools so that they could afford tax cuts for the wealthy and so that they could reduce the quality of public schools so that the public would support the privatization of the education system.

Due to the failures of American society, the American education system broke during the pandemic years. Most American school systems were not equipped with the technology required for virtual teaching and most American teachers were not trained in remote pedagogy. Even when they were, many families lacked the resources for computers for every member of the house and/or the high-quality internet connections required to support multiple family members engaging in video conferencing at the same time, meaning that many students effectively became home schooled, as they were forced to do work asynchronously.

Modeling Crises

While the impact of the COVID-19 pandemic far exceeds the impact of most crises, there will always be some crisis or another that will impact students. With each crisis, students and teachers will find that classroom interactions and climate are negatively impacted, meaning that any model should account for the impact of exogenous factors. Otherwise, the model will have limited predictive utility.

As we examine the model of the paper, we see what could be considered a good 'status quo' model, which is the standard for most models because global crises are difficult to predict and tend to overwhelm predictive models. Before 2020, it was also accepted wisdom that any global pandemic that evolved would probably mimic the slow progression of the HIV/AIDS pandemic, so it would

not have a significant impact on most predictive models (except in communities where HIV/AIDS infection rates exceeded 1%). When researchers bothered to model global crises, they were much more likely to focus on highly predictable events such as global climate change rather than highly unpredictable events such as pandemics.

While a 'status quo' model was sufficient for 2017, the pandemic has shown that such models are insufficient for reflecting real life, as 'global crisis' models are needed to have a chance of accurate predictions. Within the field of education, a 'global crisis' model would attempt to model the impact of shifting from an in-person and synchronous education system to a remote and/or asynchronous education system. Such a model could represent the impact of a 'global crisis' on every level of education, from elementary school to doctoral programs, though more advanced students would presumably have more resilience than less advanced students.

A 'global crisis' model would randomly assign every agent a value for a triggered anxiety variable and a triggered depression variable. When randomly triggered within the ABM model, the global crisis would cause a 'physical' separation of students and their teachers and students and their peers, removing the possibility of in-person interactions between students and teachers and students and their peers. It would also activate the triggered anxiety variable and the triggered depression variable.

Anxiety is important because it represents the inhibition of the development of a positive classroom climate. Teachers that experience anxiety will be incapable of facilitating a positive classroom climate while students that experienced anxiety will be incapable of responding to a positive classroom climate. In classrooms where teachers and students suffer from low anxiety levels, the climate would end up being more positive than in classrooms where teachers and students suffer from high anxiety levels.

Depression is also important because it represents the inhibition of the development of positive classroom interactions. Teachers that experience depression will be incapable of engaging students in a fashion that will develop positive relationships with their students while students that experience depression will be incapable of engaging their peers in a fashion that will develop positive relationships with their peers. In classrooms where teachers and students suffer from low depression levels, there would be more positive interactions than in classrooms where teachers and students suffer from high depression levels.

By examining the impact of global crises on classroom interactions and climate through anxiety and depression, it would be possible to assess their effects on student achievement. This means that it should be possible to model the impact of the COVID-19 pandemic on student achievement in the USA through using ABM. The impact of anxiety and depression on student achievement could also be evaluated outside of global crises, as anxiety

and depression are the most common psychological difficulties experienced by human beings.

Modeling Improvements

If the researchers of the article were willing to do subsequent research using ABM to assess impacts on student achievement, they would be well served to include a 'global crisis' models, as well as their 'status quo' models. 'Global crisis' models would potentially improve the accuracy and generalizability of their research because they would account for the impact of exogenous events on student achievement. Even if they do not cause the physical separation that was experienced by the COVID-19 pandemic, global crises will likely trigger anxiety and depression in a significant percentage of the population, which will influence anxiety and depression in students and teacher.

Another possible suggestion for modeling improvement would be to include an 'expanded crisis' model, where the anxiety and depression of the students and teachers are influenced by the anxiety and depression of the people in their lives. Since no human being is an island, the anxiety and depression of people in their lives would likely increase the anxiety and depression experienced by students and teachers. By doing so, it would be possible to model how the impact of a global crisis on a community would affect student achievement.

If the models showed that the anxiety and depression caused by a global crisis significantly decreased student achievement, it would suggest that governments should consider a more proactive efforts to address the psychological consequences of global crises. Since student achievement is directly related to educational attainment and educational attainment is directly related to future success, any reduction to student achievement could have a long-term impact on the economic prosperity of individuals. Since the economic prosperity of a societies are the sum of the economic prosperity of individuals, they could also have a long-term impact on the economic prosperity of societies.

Teaching Improvements

It seems the online challenges of teaching further exacerbated the creation of a positive classroom environment. Given the "wickedly complex feedback loops" from the Dragon King analogy, what can be done? Furthermore, once positive feedback loops are created how can negative consequences be eradicated? First most teachers, are not fully aware of the factors that comprise classroom climate and how powerful their roles as teachers can be in terms of interactions, network strengthening, and acknowledging depression/anxiety. Furthermore, few teachers know what their classroom climate is or are aware of how students emotionally experience their classroom. Given the fragile state of some students and teachers, negative behavioral markers like anger, sarcasm, irritability, harsh voice, yelling, exclusion of students, bad language, physical control of students, teasing, and bullying must be acknowledged and

eradicated. This can be done through awareness and assessment. Climate, interrelating factors, and corresponding outcomes are advantageous to examine so that teachers can recognize that changes in their leadership affect their classes' learning environments and come up with better ways to account for isolation and emotional challenges (Johnson, 2015).

Through a complexity context, researchers can provide details on the dynamics of classroom interactions as to strengthen and sustain the classroom so as to strengthen the entire system. Freiberg (1999) argued that research has not adequately addressed classroom processes of change dynamics in relation to the collective impact of processes on student achievement outcomes. "Teachers operate within a complex ecosystem of factors that contribute to (or impede) teaching and learning" (Starr & Weiss, 2015, para. 4). A noncomplexity approach has been the standard in attempts to solve climate and achievement. However, a complexity context accommodates the nonlinear relationships, bidirectional feedback loops, and time-delayed effects, which are key elements of classroom interactions that can further leverage achievement (Mabry et al., 2013). For example, standardized objective and specific feedback from classroom climate assessments and classroom observations (See Table 1-1) of visible behavior markers is a starting point. First, this process involves knowing exactly what the climate is as a starting point to employ a pre-test post-test strategy. Repeating the process over time, and

taking into account depression/anxiety, can provide more accurate feedback and trend lines to induce achievement outcomes (Johnson, 2015).

Yet what would the optimal climate in a global crisis be and what patterns of interactions could the teacher employ for positive sustainability? Important to consider is students' input on their classroom climate, given that students and teachers co-create their environment together. For example, teachers can easily solicit feedback from students on what they imagine an ideal classroom should be. This can be done through standardized research instruments (like the CES Ideal classroom survey, Trickett & Moos, 2002) or informally through assignments. Repetition of the process can provide even more valuable feedback to assess if the ideal is working or what adaptations are needed.

Additionally, teachers can create their own classroom climate feedback assessments by video recording instructional sessions in their classroom. For instance, a half hour session can provide novel feedback data even if students work on their own for part of the class. Next, teachers can count specific categories of instructional, emotionally supportive, and behavioral management interactions (See Table 1). First count the totals of all-instructional, emotionally supportive, and behavioral management interactions. Next taking a percentage of each can measure can determine the rate of instructional interactions that occur in a half hour. Teachers can then begin to determine

how the rate of instruction varies depending on type of instruction, delivery method, and varied ways students can be engaged and corresponding impact on academic achievement. Next teachers can explore how emotionally supportive and behavioral management interrelate and identify possible patterns that lead to more effectiveness (Johnson, 2016).

Table 1. Classroom Assessment Scoring System (CLASS): 10 Dimensions Linked to Student Achievement (Pianta, 2012)

Emotional support — the way teachers help children develop warm, supportive relationships, experience enjoyment and excitement about learning, feel comfortable in the classroom, and experience appropriate levels of autonomy or independence

Positive climate — the enjoyment and emotional connection that teachers have with students, as well as the nature of their interactions

Negative climate — the level of expressed negativity such as anger, hostility, or aggression exhibited by teachers or students in the classroom

Teacher sensitivity — teachers' responsiveness to students' academic and emotional needs

Regard for student perspectives — the degree to which teachers' interactions with students and classroom activities place an emphasis on students' interests, motivations, and points of view

Classroom organization — the way teachers help children develop skills to regulate their own behavior, get the most learning out of each school day, and maintain interest in learning activities

Behavior management — how well teachers monitor, prevent, and redirect misbehavior

Productivity — how well the classroom runs with respect to routines, how well students understand the routine, and the degree to which teachers provide activities and directions so that maximum time can be spent in leaning activities

Instructional learning formats — how teachers engage students in activities and facilitate activities so that leaning opportunities are maximized

Instructional support — the ways in which teachers effectively support students' cognitive development and language growth

Concept development — how teachers use instructional discussions and activities to promote students' higher order thinking skills and cognition in contrast to a focus on rote instruction

Quality of feedback — how teachers expand participation and learning through feedback to students

Language modeling — the extent to which teachers stimulate, facilitate, and encourage students' language use

Also, teachers can work on strategies to incorporate more emotionally supportive interactions that contribute to creating and sustaining a positive climate and that do not take valuable time away from instruction. For example, using the names of all students, moving toward every student, using polite language, smiling, laughing, and checking in with students to see if they are understanding the instructional interactions contribute to the co-creation of a positive learning environment. However, there is no guarantee all students will grasp instruction given (Johnson, 2016). Though, teachers have the power to activate interaction strategies for facilitative conditions for sustaining a positive climate, which research has demonstrated can increase average achievement scores up to 25% (CASTL, n.d.).

Once positive feedback loops are created sustaining a positive classroom environment, strategies to diminish negative consequences must be adopted. For example, there can be a positive learning environment but not much learning happens. As the saying goes, "you can lead a horse to water but cannot make them drink." The process of learning systems feedback needs to include student agency, student-regulation, and self-assessment feedback. According to Stiggens (2008), the most critical instructional decisions with the most impact on student success, are made by the students themselves. Self-feedback is beneficial to students because they tend to discover more value in their learning and take more ownership (Brookhart, Moss, & Long, 2009). Loveless (2022) claims student self-assessment is simple, whereby students need to determine what they were supposed to learn, did they learn it, and do they have any additional questions. For example, see Figure 2 below.

This type of approach could prove even more effective with "immediate" feedback with technology like an app, that funnels data directly to instructors so they can adapt to meet students' learning needs in a timely fashion. This is a research direction we propose to further explore. Certainly, this approach will not prevent all negative consequences. However, this type of feedback loop is flexible, effective, and easy to apply (Leahy et al., 2005).

Suggestions for Future Research

Future researchers should consider including Dragon Kings in their models when using ABM, as doing so would improve the accuracy and generalizability of their models. While Dragon Kings are rare phenomena, they can produce global crises that change human society, meaning that they will limit the utility of any research that does not attempt to account for their impacts. By not accounting for the existence of possible Dragon Kings, researchers do themselves a disservice because they limit the accuracy and the generalizability of their studies.

While the COVID-19 pandemic will eventually end, there will be other global crises, especially as global climate change continues its progression due to the shortsightedness of world leaders. Dragon Kings will continue
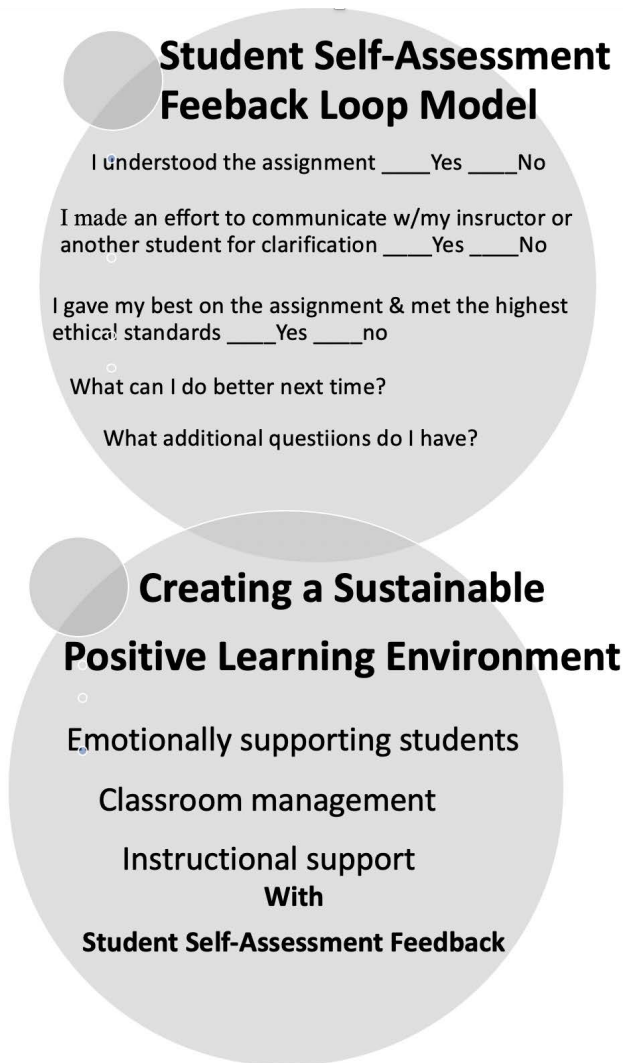
Student Self-Assessment Feeback Loop Model

I understood the assignment ____Yes ____No

I made an effort to communicate w/my insructor or another student for clarification ____Yes ____No

I gave my best on the assignment & met the highest ethical standards ____Yes ____no

What can I do better next time?

What additional questiions do I have?

Creating a Sustainable Positive Learning Environment

Emotionally supporting students

Classroom management

Instructional support
With
Student Self-Assessment Feedback

Figure 2. Student self-assessment feedback model interrelating with elements of creating a sustainable positive learning environment.

to arise from the mistakes of humanity, whether they were caused by avarice, ignorance, or malice, and they will disrupt human society. Of course, researchers will need to clearly state their assumptions concerning their modeling, as different types of global crises will have different impacts on the population. As Bethune implored, "we must have the courage to change old ideas and practices" (Bethune, 2000, p.

395). Finally, teachers must deal with uncontrollable influences from outside the classroom. They have agency and power to create a positive or negative climate by their verbal and nonverbal interactions. Teachers' interactions have consequences that impact students' achievement, emotional states, and students' lives. Consequently, every interaction matters (Johnson, 2016).

References

Bethune, M. M. (2000). Youth. In R. Newman (Ed.), African American quotations (p. 395). New York, NY: Oryx Press.

Brookhart, S. M., Moss, C. M., & Long, B. A. (2009). Promoting student ownership of learning through high-impact formative assessment practices. *Journal of Multi-Disciplinary Evaluation*, *6*(12), pp. 52–67. https://journals.sfu.ca/jmde/index.php/jmde_1/article/view/234

CASTL. (n.d.). Measuring and improving teacher-student interactions in PK-12 setting to enhance students' learning. Retrieved December 18, 2015, from http://curry.virginia.edu/uploads/resourceLibrary/CLASS-MTP_PK-12_brief.pdf

Freiberg, H. J. (Ed.). (1999). School climate: Measuring, improving and sustaining healthy learning environments. Philadelphia, PA: Falmer Press.

Johnson, L. (2015). A network context for observing and mapping of Ghana mathematics classroom interactions. *International Journal of Humanities and Social Science, 5*(1), 1-19.

Johnson, L. (2016). A complexity context to North Carolina charter school classroom interactions and climate: Achievement gap impacts (#13035) [Doctorial dissertation]. ProQuest.

Leahy, S., Lyon, C., Thompson, M., & Wiliam, D. (2005). Classroom assessment: Minute by minute, day by day. *Educational Leadership (63)*, 3, pp. 18-24.

Loveless, B. (2022). Helping students thrive by using self-assessment. Education Corner. https://www.educationcorner.com/helping-students-self-assessment.html

Mabry, P. L., Milstein, B., Abraido-Lanza, A. F., Livingood, W. C., & Allegrante, J. P. (2013). Opening a window on systems science research in health promotion and public health. *Society for Public Health Education, 40*(1S). doi: 10.1177/1090198113503343

Pianta, R. C. (2012). CLASS dimensions guide. Charlottesville, VA: Teachstone Training LLC.

Ricci, P.F. & Sheng, H.-X. (2017). Accessing catastrophes-Dragon Kings, Black, and Gray Swans-for science-policy. *Global Challenges, 1*(6), n/a. https://doi.org/10.1002/gch2.201700021

Sornette, D. (2009). Dragon-kings, black swans and the prediction crisis. *International Journal of Terraspace Science and Engineering* (2). pp.1-19.

Starr, J. & Weiss, E. (2015). 5 questions policymakers need to ask about Common-Core test results. Education Week. Retrieved from http: www.edweek.org/ew/articles/2015/10/07/5-questions-policymakers-need-toask-about.html

Stiggins, R. J. (2008). *Student-involved assessment FOR learning.* Pearson Merrill Prentice Hall.

Trickett, E. J., & Moos, R. H. (2002). A social climate scale (3rd ed.). Menlo Park, CA: Mind Garden.