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Abstract

The successful dissemination of the Peer-Led Team Learning (PLTL) model at multiple institutions of higher education, in the United States and other countries, is reflected in the number of publications (see www.pltlis.org). However, many PLTL campus programs are no longer active or exist. This may be due, more recently, to the COVID pandemic and its disruptions. Historically, programs no longer exist because grant funding that supported the initiative ended; other reasons include the promotion, retirement, or even death of the practitioners whose work championing their PLTL program ended. What can sustain a campus PLTL program so that its benefits continue to accrue to students and Peer Leaders, and positively affect institutions' retention, graduation rates, and mission over decades? This paper examines the strategies used to disseminate the PLTL model; presents suggested prescriptions for institutional adoption regarding climate, culture, and organizational learning; provides case studies of possible sustainability methods and compares the PLTL critical components to suggestions for creating sustainable educational innovations.

Keywords: Sustainability, Institutionalization, Peer-Led Team Learning, Mattering, Dissemination, Propagation, Climate, Culture, Organizational Learning, Department

Introduction

What does it matter if a Peer-Led Team Learning program disappears? Such a question is the other side of the arc, infrequently explored when a program is started. Jack Kampmeier, one of the founders of the Peer-Led Team Learning (PLTL) model, would ask, "What is the problem… [with students' performance, retention in first-year courses, and continuation to higher-level courses]?" (Kampmeier and Varma-Nelson, 2001). Such questions were the impetus to the use of PLTL in the early 1990's. The successful dissemination of the PLTL model at multiple institutions of higher education, both in the United States and in other countries, is reflected in the number of publications that present data on students' success with PLTL as well as newer research questions such as the nature of discourse (see https://pltlis.org/publications). However, many PLTL campus programs are no longer active or have disappeared. In some recent cases, this may be due to the COVID pandemic and its disruptions. Historically, programs no longer exist because grant funding that supported the initiative ended; or the initial practitioners – usually faculty members– were promoted, retired, or died, and their efforts as champions for their PLTL program ended.

What can support sustainability of a campus PLTL program so that its benefits continue to accrue to students and Peer Leaders, and positively affect institutions' retention, graduation rates, and mission over decades? The topic of sustainability of innovations is seldom examined (Arendale, 2022). This paper examines the strategies used to disseminate the PLTL model; presents suggested prescriptions for institutional adoption regarding climate, culture, and organizational learning; provides case studies of possible methods of sustainability and compares the PLTL critical components to suggestions for creating sustainable educational innovations.

Instructional pedagogy as innovation: Challenges to adoption

Of all the students who intend to graduate with a Science, Technology, Engineering or Mathematics (STEM) bachelor's degree, only about 40% have succeeded over the past thirty years (Apkarian et al., 2021). The introductory courses for STEM degrees in chemistry, calculus, and physics are called either "gatekeeper" or "gateway" (with the intent of "weeding out" students who are "unqualified"). Yet evidence suggests that the low passing rates and the methods used to teach affect students' learning experiences. Worse, "while increasing numbers of women and students of color enter STEM majors, they continue to leave at high rates, indicating a continued and substantial loss of natural talent and interest in the sciences" (Apkarian, et al., 2021, p. 2).

Gafney (2012) suggests some reasons why traditional lecture as an instructional method has not succeeded in supporting students in the gateway courses:

- STEM courses have become more conceptual and more quantitative;
- More students who have not had a solid foundation in mathematics and the sciences are going to college and intending to major in STEM areas.

Further, he suggests that additional demands for career development are not supported by the lecture method:

- Teamwork is needed in jobs and careers, but little opportunity is afforded in introducing students to its practices;
- Communication skills, whether oral or written, are necessary for many STEM careers; there is the need to acquire the language of knowledge in course material and to develop fluency in expressing those concepts for understanding, discussion, and debate.

Active learning instructional strategies (e.g., Allen & Tanner, 2005), called Research Based Instructional Strategies (RBIS) by Froyd (2010), have empirically "promote[d] content understanding, attitudes, and retention among all students, and reduce[d] achievement gaps between dominant and underrepresented groups in STEM" (Apkarian et al., 2021, p. 2; Freeman et al., 2014). As Allen and Tanner (2005) note, it is important for instructors

> to adopt active-learning strategies and other alternatives to uninterrupted lectures to model the methods and mindsets at the heart of scientific inquiry, and to provide opportunities for students to connect abstract ideas to their real-world applications and acquire useful skills, and in doing so gain knowledge that persists beyond the course experience in which it was acquired (p. 262).

Yet the many strategies and instructional methods are not readily adopted. What beliefs might influence instructors to adopt such strategies? Apkarian et al. (2021) surveyed 3769 instructors in various types of institutions on six beliefs, often cited as barriers to adopting RBIS, three focused on *contextual factors*: class size, classroom setup, and teaching evaluations; and three focused on *individual factors*: security of employment, research activity, and prior exposure to active learning. Of the contextual factors, active learning strategies were not a barrier *per se*, as some instructors used such strategies despite large class sizes and inconvenient class setups. Teaching evaluations were perceived as having weight for tenure and promotion decisions, dependent on institutional contexts.

Of the individual factors, security of employment, or lack thereof, did not affect the use of active learning strategies. Research activity was a factor: very active researchers, as shown by the number of publications, grants, and presentations, did tend to lecture more than non-research active instructors. However, those researchers involved in education research tended to use more active learning strategies. And those instructors who had experienced active learning as students used active learning strategies in their instruction. However, few instructors surveyed had experienced such instruction.

Brownell and Tanner (2012) write that the explicit barriers to the adoption of active learning strategies often mentioned a lack of training, time, and incentives. They suggest that an additional barrier is a professional identity. An implicit barrier, the years of preparation as a researcher in a specific segment of a discipline preclude concomitant preparation as a teacher. "…[T]here is a profound disconnect between the training that students are receiving in doctoral programs and the careers that many of these students will ultimately enter" (p. 341). Professional identity as a researcher is considered higher status than as a teacher, which is "reinforced by the general salary and status structures with regard to teaching within our society, in which teaching is generally considered to be not as well compensated for or afforded as much respect as many other professions" (p. 342). Thus, even those graduate students interested in instruction "fear that they will be marginalized and discriminated against by their scientific peers and mentors" (p. 342).

Diffusion, dissemination or propagation models

Promoting change in instructional practices by faculty and instructors, moving from lecture to implementation of other teaching strategies, has been met with resistance. Despite the empirical evidence of the efficacy of many active learning strategies, institutional reward structures have not promoted adoption, with the result that many instructors have not been convinced enough to try them (Seymour 2002, as noted by Stanford et al., 2017).

Informing potential adopters about active learning instructional strategies has been tried through at least three paradigms. These include the diffusion of innovation model (Rogers, 2003), the dissemination model which has been widely used by those with grants from the National Science Foundation, and the more recent propagation model.

The diffusion of innovation model to potential adopters posits that adoption of an innovation has the following attributes: (1) relative advantage—perceived benefits compared to existing practice; (2) compatibility—perceived consistency with individual needs and values as well as consistency with practice in the local instructional system; (3) complexity—perceived difficulty to understand and apply; (4) trialability—perceived ease of giving it a try;

and (5) observability to people within the social system (Froyd et al., 2017). Gafney (2012) observes that (1) faculty interested in changing their students' performance often have examined various models before adopting PLTL; (2) contextual factors in solving – the problem – helps determine whether PLTL is a suitable fit. Gafney notes that an additional factor for instructors is their willingness to trust Peer Leaders to facilitate their workshop sessions. (3) Complexity is a factor when adopting PLTL: implementation may be perceived as daunting when faculty are not habitually used to finding space, scheduling issues, meeting with Peer Leaders, and coordinating administrative tasks. (4) Trialability suggests that piloting a PLTL project may seem daunting, because of levels of complexity and compatibility. Gafney does not directly address the fifth factor – observability by others – but notes, in indicators of institutionalization, that a "core group of dedicated faculty" is necessary: "one person cannot sustain PLTL" (p. 7).

The dissemination model, for many years a component of grant proposals submitted to the National Science Foundation, has been criticized as "passive" in that innovators broadcast their product through presentations, websites, and publish findings of its use. This model has been critiqued for its lack of feedback and revision from those who may find the innovation useful (Stanford, et al., 2017).

King (2003, as noted in Stanford et al., 2017) suggested a third model, "propagation," a way of "grafting" dissemination through three stages: scattering (distribution of information), sowing (targeted distribution of information), and propagating (use of innovation by others). Stanford, et al. (2017) note that dissemination, the scattering and possibly even sowing - the process of spreading information - focuses on getting the word out to potential adopters, creating awareness. Yet innovation can be disseminated even if no one beyond the developers has adopted it. On the other hand, propagation is understood to "result in sustained adoption of innovations" (p. 419), beyond the original development team. Propagation requires developing a product responsive to the needs, interests, and situations of potential adopters; getting the word out to potential adopters, motivating potential adopters to try the innovation, and developing mechanisms to support adopters so that they continue to use the innovation. The timing of the phases of propagation moves from the development phase, when an innovation is created that is usable; the revision phase when the innovation is tested by users and improved; and the expansion phase when the innovation is used by many adopters. This model of innovation is suggested by technical product development, where a "minimum viable product" is introduced, used, revised, and brought to market (e.g., I-Corps-L, National Science Foundation, 2015).

The propagation model is further delineated by Froyd, et al. (2017). The *efficacy* of an educational innovation is demonstrated in achieving the intended outcomes—usually improvements in student learning. The *fit* of the innovation is how well it works with the instructional system and/or the pedagogical beliefs of potential adopters. Further, *affordances* are aspects of the instructional system that provide support and/or changes to teaching practice while *barriers* prevent or deter change (p. 37).

The Peer-Led Team Learning model, building on its predecessor, "Workshop Chemistry," was purposefully "disseminated" into disciplines beyond chemistry and in various types of campuses (Dreyfuss, 2013). Supported by grants from the National Science Foundation, faculty from consortia of institutions used a four-tier model (Gafney, 2012; Gosser et al., 2010).

(1) Stimulating interest (creating awareness) focused on presentations at conferences and departmental meetings, publications in journals (see publications, PLTLIS.org), as well as Project activities such as its website and publication of *Progressions*, the Workshop Project quarterly newsletter.

(2) Creating a deeper understanding through an immersive experience. The NSF-sponsored Chautauqua program (1998) for faculty development was used to host two workshops a year focused on PLTL, initially in Philadelphia and Pasadena, for two and a half days each. Other outreach workshops sponsored by the National Science Foundation included the Multi-Initiative National Dissemination (MID) Project, which presented PLTL and other models of active learning based in the discipline of chemistry, promoting systemic change in teaching. Workshops were also sponsored by organizations or individual departments.

In addition, the development of chemistry materials (Woodward et al, 1993), which initiated "Workshop Chemistry" spurred the development of five workbooks published by Prentice Hall, three for chemistry courses, one guidebook (Gosser, et al., 2001); and one handbook for peer leaders (Roth et al., 2001).

(3) Workshop Project Associate (WPA) Program: Implementation through a funded pilot program: The WPA program provided seed money to try the model, usually by a single faculty member. Requirements included participation at a Chautauqua workshop or agreed equivalent workshop; demonstrated familiarity with the six critical components of the PLTL model, used in developing and submitting a short proposal (about three pages), and obtaining matching funds from the institution.

(4) Developing scholarship and leadership: activities included the Annual leadership conference; continuing scholarly publications and research. This education research

initially focused on student outcomes, then Peer Leader outcomes. Presentations at annual conferences turned into papers for *Progressions* or other publications. However, the explicit development of ongoing leadership was not addressed.

How did the PLTL dissemination model compare to the propagation model?

Table 1. Comparison of Propagation Model (Stanford, et al., 2017) and PLTL Dissemination Model (Gosser, et al., 2010; Gafney, 2012)

Themes of Propagation	**Propagation Model (Study of Type 1, CCLI NSF grants)**	**Peer-Led Team Learning Dissemination Model [funded by NSF]**
Theme 1: The Importance of Understanding Potential Adopters and their Instructional Systems	Identifying potential adopters; acknowledging differences and limitations of the instructional systems in which their potential adopters worked	[Pre-grant development and grant oversight] Project consortia of faculty from various institutional types: Research 1 to community colleges (both Workshop Chemistry (1995-2000) and Dissemination grants (1999-2006)
Theme 2: The Value of Engaging Potential Adopters	By engaging potential adopters, the PIs were able to learn who the potential adopters and decision makers were for their innovation and how they could target these specific audiences more easily.	[Active ongoing evaluation across implementations/campuses] Engaged faculty in STEM disciplines and types of institutions; PLTL model of Six Critical Components developed through multiple evaluation strategies in "Workshop Chemistry" phase
Theme 3: The Importance of Using Interactive Dissemination Strategies	Mixture of interactive and passive strategies: posting materials to an existing website, connecting with potential adopters using listservs, and having promotional materials like pamphlets.	[Stage 2] Workshops are developed to introduce the 6 critical components and how to apply them in a variety of contexts to provide *fit*; encouraging data collection to present results, from evaluations across campus types provided evidence of *efficacy*
Theme 4: Support	Support of potential adopters, materials provided as examples; tracking and contact of adopters; some adopters applied for additional funding	[Stage 3] WPA grants provided through proposal process after attending workshop. Materials – shared drafts of chemistry problems; other materials, including training of Peer Leaders. Participant lists from conferences, workshops, WPA program recipients. Dissemination project team – listed on website, *Progressions*; publications
(Continued Support)	Adopters sustained innovations through funds from other sources or stopped supporting the innovation for lack of funds, due to a lack of infrastructure to provide ongoing support for educational innovations	Encouragement of [NSF] Adopt/Adapt grants (consortia); STEP grants; regional workshops; Significant NSF support: MIE, other grants HHMI also funded Biology PLTL efforts
Theme 5: Successful Propagation Involves More than	Developing a stronger product and making sure that it meets the needs of their potential adopters. Those able to	Local variations in PLTL implementations; continued development by faculty; shift to support from Student Learning Centers;

Themes of Propagation	Propagation Model (Study of Type 1, CCLI NSF grants)	Peer-Led Team Learning Dissemination Model [funded by NSF]
Developing a Product that Works Well Locally	provide some follow-up and support mechanisms, regardless of the difficulties, were able to transition to the expansion phase.	continued application for grants to funding agencies by new campuses; creative funding mechanisms.

Stanford et al. (2017) conclude that a focus on propagation is necessary, especially for innovations that require substantial change to existing practice, and that assistance be included in the plans to support adopters to make those changes. However, "if innovations are to be effectively propagated and sustained, there need to be changes in infrastructure and funding models…but additional work is needed to support the education community in designing for sustained adoption" (p. 435).

The dissemination of PLTL was a sophisticated effort and its backbone of the six critical components (with local variations to meet contextual conditions) has made it both a recognizable and sustainable program – where there are "champions" (Dreyfuss, 2016). These are usually faculty or instructors who find the benefits of PLTL of greater importance for students' performance, and development of leadership in Peer Leaders, even with the recognition that there is an organizational dimension to implementation. Incorporating a program has a dimension of routine and administration.

Once incorporated into practice in a course – whether first-year, gateway, or higher-level – or even several courses within a department (e.g., the Biology Department at Florida International University; see Alberte, et al., 2013a and Alberte, et al., 2013b), a routine cycle is established:

- Students register for a weekly workshop session, attend lecture and workshop
- Peer Leaders are recruited, selected, and prepared for their role (preferably with a Learning Specialist)
- Faculty meet weekly with the Peer Leaders to review the materials, obtain feedback on understanding, and may discuss facilitation and other support
- Materials may be developed and reworked to remain challenging
- Data may be collected for research purposes and institutional support.

What distinguishes the Peer-Led Team Learning model is its six Critical Components, developed by Gafney (2012):

1. Integration with the Course. Students who are in a workshop program are expected to attend all the workshops. These are not drop-in sessions. Students should experience

the workshops as closely coordinated with lecture and homework and contributing to their success in the course.

2. Involvement of Instructor. Ongoing involvement of the faculty member keeps the leaders involved and provides a necessary ongoing course connection.
3. Training of Leaders. Leaders are the all-important ingredient in establishing successful workshops. Selecting, preparing, and supervising good leaders is the key to shaping the workshop dynamics and quality. Active discussion of course material is facilitated by the Peer Leader.
4. Appropriate Materials. Materials are developed or adapted with the purpose of developing skills, promoting problem-solving, working well with groups, and by reviewing topics recently taught, providing deeper understanding.
5. Organizational Arrangements. The workshops are intended for small groups of six to eight students, with adequate space and materials for group work and discussion. Two hours is the recommended time, but programs use the amount of time that is available.
6. Departmental and Institutional Support: Resources and recognition are essential if the workshops are to continue.

As Gafney notes (2012), through multiple evaluation means, "whenever PLTL was struggling with implementation, not finding success, and not really valued by faculty and students, problems could be identified in one or more of the critical components."

Notably, the first component places faculty/instructors in the key position of implementers; the second and fifth describe the need for institutional resources, while the fourth speaks to the need for materials that support discussion and group problem-solving. The third component is the truly distinguishing characteristic of the model: the involvement of Peer Leaders, students who have successfully passed the course and now are selected and prepared to lead students in learning the course material in groups. The students must face each other; speak with each other; listen to each other and develop their understanding of the course material. The sixth component speaks to the larger context of institutional support: colleagues, department, school, and institution. Institutionalization of the model is indirectly addressed, which also suggests that data regarding assessment and retention will continue to benefit the institution. Thus, sustainability is assumed.

Gafney and Varma-Nelson (2008) posit the following indicators "that PLTL will continue at an institution and suggest them as components needed if any educational program is to endure" (p.75):

1. Implementation according to the model and on-going fidelity to the model [six critical components]
2. Administrative support and funding
3. Perceived success, particularly in student learning
4. Fit with the institution's mission and practice
5. A core group of committed faculty

How do these indicators (Gafney & Varma-Nelson, 2008) map for sustainability?

A core group of committed faculty [5]

The assumption from the initial development of PLTL by faculty at various institutions was that the potential adopters would also be faculty or instructors, like themselves, who wanted to make changes in their teaching practices. Walter et al. (2021), in considering factors of culture and climate for instructional change practices, suggest that "Collegiality in academia is enigmatic. Instructors may be socialized to 'not care' what others think, do work that is isolated from one another (like teaching), and fight for limited resources" (p. 184).

The faculty and instructor adopters of PLTL could be termed "change agents" to indicate persons effecting needed changes. Yet, as described by Froyd et al. (2006), there are roles for other "actors" in the change process:

> *Change agents* are the people who are charged with actually implementing the change process. Their focus is on facilitating the change process in an attempt to realize the goals of the project. Other individuals may take positions of advocates of particular strategies intended to achieve the change. Both are important to success. *Advocates* construct arguments regarding advantages of specific approaches. Change agents work to facilitate processes through which faculty members engage various alternatives. Without advocates, no one may do the hard work of investigating, analyzing, and constructing a particular alternative. Without change agents, advocates and *other faculty members* may clash in unproductive discussions. [There are] various change agents, including *department heads*, *curriculum committees*, *ad hoc task forces*, and individual faculty (p. 6).

A case study of transition in a mathematics department

Short workshops do not facilitate institutional change, according to Henderson, et al. (2011). Systemic change, noted by Dagley et al. (2018), demands a focused intervention that

incorporates reflection. The Mathematics Department of a large metropolitan university used a cognitive apprenticeship model. The program, MATH-GAINS, was also a learning community (LC) of faculty and graduate teaching assistants, focused on the teaching of courses in Calculus, active over a two-year period. Faculty LCs were a forum for exchange of information regarding evidence-based teaching strategies in an environment that nurtured support for the implementation of these practices. MATH-GAINS participants focused on developing mathematical understanding utilizing strategies centered on active engagement, effective use of technology and classroom assessment techniques. Faculty selected from a menu of evidence-based practices and developed learning materials that incorporated these practices in math courses over a two-semester period. Activities of the project also included:

(1) regular (semi-weekly) math education seminar series which showcased teaching practices and results from faculty both inside and outside the department, promoting regular exchange of ideas;

(2) one mathematics colloquium devoted to mathematics education each year. These colloquia invited experts from outside the university and were attended by most of the department;

(3) the department hired a tenured professor who had secondary research interests in math education, and a tenure-track faculty member whose primary research interest is math education. As there were no other faculty in the department with the same primary research focus, this denoted a significant change, reshaping the role of mathematics education research within the department;

(4) changes in the department have resulted from the actions of faculty who participated in the MATH-GAINS program: four MATHGAINS faculty participants serve on the department's Calculus Committee; one of the four is serving as the committee chair. Notably, the committee continues to gather and analyze data in order to better understand failure rates, and are actively pursuing changes to course design, materials and curriculum;

(5) A new Mathematics Education Committee was created to assess, promote, and implement further developments, now that the MATH-GAINS program has officially ended.

Sustainability was an underlying framework through the involvement of department members.

A case study in generational transition

Grimes and White (2015) provide a rare case study on how a retiring professor provided scaffolding to a new professor in how to teach with active learning strategies, in this case, Problem-based Learning (PBL), over a three-year period. "Change is a long-term investment that can be effective when change is directed to newly hired faculty who are beginning their careers… new faculty [should] be actively mentored and encouraged to adopt research-based instructional strategies" (p. 355). Grimes and White describe their collaboration as a "successful apprenticeship strategy," noting that "workshops fail to relay all of the techniques that go into effectively running a PBL classroom" (p. 354). Their strategy was frequent interaction, involving apprenticeship including modeling, scaffolding, fading, and coaching.

As an alternative to such an apprentice model, they recommend that "faculty interested in adopting research-based instructional strategies should consider a teaching sabbatical where they can be mentored and gain practical experience by co-teaching with an experienced practitioner…Apprenticeship works, but it takes time and will not transform the culture overnight" (p. 354).

Administrative support and funding [2]

At what level is change promulgated for sustainability? Are the faculty (instructors) the initiators of change? Is the department the suggested locale? Walter et al. (2021), in their survey of factors involved in *instructional improvement,* note their starting point in an academic organization is the department as a key leveraging point for change. Further, "the *department chair* is at a unique intersection of resources, policy, and collegiality; they are both in power and a peer, empowering them to be important loci of organizational change" (p. 183). Quardokus Fisher & Henderson (2018) concur:

> Department-level change frames our argument. Recent studies of the process of change in higher education have argued it is critical to understand and focus on department-level change, because departments typically make decisions regarding curriculum and tenure, and department members often discuss their instructional views in both formal and informal venues (p. 17:ar56, 2).

Individual change is not enough, according to Henderson et al. (2011). They posit that while departmental change includes individual change, change initiatives need to be situated within the larger institutional system. This view suggests that there is a top-down reason to

change (for example, changes prescribed by accreditation agencies), affecting the many parts of the institution. However, it is the individual's dissatisfaction with the problem that drives the desire for change. This suggests an emergent framework, based on complexity leadership theory, that acknowledges a "bottom-up" or "grass-roots" effort, and the vision of expected change evolves during the process of change (based on Uhl-Bien and colleagues, 2007 as noted by Quardokus Fisher & Henderson, 2018).

While complexity leadership theory identifies the roles of administrative, adaptive, and enabling leadership in the change process, these roles of formal *leaders, innovators,* and *change agents* have not been actively present in many PLTL campus implementations, with the faculty/instructor as the sole adopter. Working alliances between formal leaders of student learning centers and faculty are examples of institutional adaptation and incorporation of PLTL. Such examples include the University of Rochester (Platt et al., 2008) and the University of Texas at Arlington (Hickman, et al., 2021).

Quardokus Fisher and Henderson (2018), in discussing leadership theory, note that institutional change is subject to abandonment when leadership change occurs. While their discussion is prescriptive to model change at the beginning of a change cycle, the result of abandonment is true even when the implementation of active learning instructional strategies, such as PLTL, has succeeded, but the "champions" – whether faculty or formal leadership – changes, through promotion, retirement, or other events. They caution that, "If the department chair is not supportive of change, then a change agent may need to think of creative ways to address the core objectives.... The necessary aspect of this strategy is support" (p. 14). Such a strategy is evident in the creation of extra-organizational support in the PLTL program at the University of Texas at El Paso (Becvar & Saupe, 2021).

Fit with the institution's mission and practice [4]

How can instructional practices be changed? The institutional context must be brought into the discussion. "The *culture* of an organization is embedded and enduring and difficult to change. It is manifested in values, beliefs, myths, and rituals. The *climate* of an organization is considered more malleable to change than culture and includes the current patterns or atmosphere of an organization" (Walter, et al., 2021, p. 168). The climate for *instructional improvement* is defined as the action or process of making changes in instruction to achieve the best possible learning outcomes using reform-based instructional strategies, technologies, and/or curricula. Factors involved in *instructional improvement* were delineated based on the data from a survey instrument that elicited organizational climate, with the stated assumption

that the starting point in an academic organization is the *department as a key leveraging point for change*.

One of the *factors* noted by Walter and colleagues is the availability of *resources*, including (a) time (b) money incentives (c) teaching space, and (d) autonomy in content and pedagogy, to be considered at the departmental level. Another factor is *organizational support* for instructional improvement, which includes professional development, mentorship, structured pedagogy groups, and financial incentives, all items usually beyond the department's infrastructure.

Organizational learning is when knowledge and processing of information are acquired in one area of an organization which can be useful to the whole organization. A study by Kezar and Holcombe (2020) examined barriers to organizational learning across several institutions and found that great attention is paid to campus context and culture, to the point that faculty and administrators felt they could not learn from other institutions: "Not invented here," even distrusting research and data from those institutions. Competition between campuses also fostered the idea that homegrown ideas were best suited for their campus, preventing learning about other campuses' experiences. Another issue that surfaced was working with only some of the stakeholders, e.g., upper administration, which prevented learning about faculty, staff, or students' experiences. Finally, not being open about issues and questions that may arise prevented learning, even when expertise and answers from other sources would have proved helpful.

Case study of institutionalization of PLTL

At the University of Rochester, beginning with courses in organic chemistry and biochemistry that incorporated PLTL workshops, student improvement in exams was noted by faculty, administrators, and students:

> In practice, these three groups also paid particular attention to student testimony and enthusiasm. The continuing high level of unforced participation in the organic chemistry Workshops provided compelling evidence that students value the Workshops; they are literally voting with their feet. Students talk to other students, of course, as well as to faculty and administrators, and their voices, added to those of the peer leaders, played a major role in building continuing support. As word spread, a spontaneous network of interest that transcended the individual courses began to grow. This was particularly crucial in obtaining budget increases for peer

> leader stipends and money, and time for staff from our learning center to co-teach the leader training course (Platt, et al., 2008, p. 147).

What Jack Kampmeier, professor of organic chemistry at the University, called the "Rochester clock" began. The PLTL model was adopted in more and more courses: second semester of organic chemistry, first-year biology, and general physics became Workshop courses. Peer Leaders from organic chemistry, in their role as students, lobbied the faculty to add Workshops to the other courses. Then more faculty adopted the Workshop model for their own courses, even Quantum Chemistry.

Platt and colleagues reported that in the 2008-2009 academic year, fifteen to twenty Workshop semester courses with accompanying leader training courses were offered in eight departments; some 250 Peer Leaders facilitated the Workshops for about 2500 students. They note that "the propagation of the Workshop model to other departments probably could not have been accomplished by a chemistry faculty member" (p. 147).

Further support was through the "Workshop Task Force," an ad hoc group of faculty and learning specialists that met regularly to share and disseminate ideas and development of workshops in more courses. Those with more experience helped those who more recently implemented PLTL in their courses, thus creating a community of practice (Lave & Wenger, 1990).

Issues in scheduling times and meeting spaces for the workshops were brought to the Registrar (formal institutional leader); librarians (formal leadership) also provided additional spaces. The University's mission of supporting research tied in to "The central idea that Workshop is a place for students to explain, discuss and negotiate their understanding of concepts and ideas and learn to make up their own minds is a good fit with the goals of the curriculum" (p. 148). Despite personnel changes among deans, chairs, and course instructors, the success of the Workshop program in high-enrollment upper-level courses created visibility and change, including reliable funding, continued propagation in more courses, and the establishment of a Center for Workshop Education (Platt, et al., 2008).

<u>The role of Peer Leaders and perceived success, particularly in student learning [3]</u>

As noted by Platt and colleagues (2008), the student Peer Leaders were instrumental in spreading the practice of PLTL Workshops because they understood how they and their peers, the students in Workshops, benefited. Not only did students have better examination scores, but they also had a better understanding of the course material, allowing them to succeed in upper-level courses.

There have been many studies on the effect of PLTL workshops on student learning. Early evaluation efforts by Gafney (2001) demonstrated that PLTL was effective in raising exam scores, increasing the percentages of ABC grades, and lowering DFW rates, leading to what Gosser et al. (2010) called the "PLTL Boost." Other studies have demonstrated the effect on supporting women and underrepresented students (e.g., Snyder, et al., 2016; Hickman, 2016; Preszler, 2009).

Grimes and White (2015) note that "peer facilitators" are critical to the success of the course: "Their role is to help the groups to function effectively" (p. 349). The peer facilitators with whom they worked also took a course that discussed pedagogical issues. Grimes and White state that the peer facilitators serve as "apprentices," novice experts who are "legitimate peripheral participants" (Lave & Wenger, 1990) to the active learning method with which they are involved in practice. Grimes and White write that "several students…who served as peer facilitators have become faculty who use active-learning pedagogies in their teaching" (p. 354). This early method of inculcating active learning pedagogies has been noted through the facilitation skills afforded Peer Leaders with the practice of PLTL (e.g., Amaral & Vala, 2009; Streitwieser and Light, 2010).

Implementation according to the model and on-going fidelity to the model [6 critical components] [1]

[Component #1] Faculty and instructors are the first-level change agents with Peer-Led Team Learning. It is their dissatisfaction and frustration that promotes looking for a way to help students, "to see the beauty of organic chemistry," as Jack Kampmeier would say.

Smith (2012) mentions the need for hands-on workshops for instructors and staff to be aware of strategies and become skilled at using them (although she is discussing technological training) and have time to implement them in their courses. Apkarian et al. (2021) suggest that instructors may get experience through co-teaching or participating in an instructional development team. Smith mentions rewards of cash, software, and materials; other incentives may include release time to meet with Peer Leaders and with others who are implementing the changes as well. As Smith notes, "People have to feel they possess the skills necessary to work differently" (p. 176).

Two suggested methods to support faculty to practice active learning strategies are through apprenticeships and mentoring, such as Grimes and White suggest; and through institutional support for faculty development, including involvement in communities of practice after extensive immersion, such as shared with the MATH-GAINS effort (Dagley et al., 2018).

[Component #4] Materials need to be challenging to foster discussion, with no answer keys provided to students in workshop sessions. The materials may be developed with the aid of Peer Leaders and colleagues teaching the same courses, as an activity that promotes focus on what students need to learn to succeed, not only in the immediate course but as the foundation for higher-level courses.

[Components #5 & #2] As discussed by Platt et al., (2008), infrastructure issues of space, time, scheduling, and inclusion of PLTL Workshops as an integral part of courses can be negotiated with the appropriate administrative offices. Issues noted by Apkarian et al., 2021 regarding class size and classroom setup change with the incorporation of PLTL: small groups of students (ideally, six to eight; practically, ten to sixteen) meet in spaces that have movable furniture, preferably around tables, with boards to allow shared viewing of thinking about solutions.

As Smith (2012) notes, infrastructure needs to be in place. She was addressing the need for technological and technical issues to be in place, and these are pertinent for active learning strategies as well. The use of clickers, videos, the use of computers, and cell phones, for example, are prevalent and in use already. Online workshops have also been workable since 2011, from "cyber PLTL" or cPLTL (Mauser, et al., 2011) to COVID-related opportunities (Dreyfuss, et al., 2021).

[Component #3] Peer Leaders are students who are selected, prepared, and supported for their role to help students learn. Apkarian et al. (2021) and Smith (2012) note that those with prior personal experience with the innovation are more likely to use innovative practices. Authentic learning experiences should be accompanied by opportunities to discuss those experiences, ideas, and reflections (Smith, 2012). Peer Leaders not only lead weekly workshops; they usually have set times to meet with instructors to review the workshop sessions: what went well or not, what issues arose, and what material was not understood. This provides a feedback loop for the instructor that helps align course content with students' understanding. Peer Leaders, at many campuses, may also have a course in the theories of learning and techniques, and group dynamics (e.g., Platt, et al., 2008). These may have journal writing as a component (even uploaded to "learning management systems" such as Blackboard or Canvas). These provide further opportunities for reflection. There may also be final projects, such as posters or papers, providing reflection on practice, and scholarship of learning (Jalloh, et al., 2021; Dreyfuss and Gosser, 2006). The creation of community around an innovation means that Peer Leaders (as well as faculty and others) should be seen as "active learners rather than individuals who can be trained" (Smith, 2012, quoting Wolff, 2008, p. 1195).

[Component #6] Both institutionalization and sustainability of innovative practices such as PLTL need several supportive mechanisms. Forhan (2012) enunciated what someone in a dean's position would need, to "bind Peer Led Team Learning so into the culture of the University that it becomes the norm, and its model of teaching is seen as business as usual" (p. 1). From an administrator's perspective, PLTL's value relates to the institution's mission and goals, as observed by accreditors and for a public institution, legislators who fund it. How does PLTL meet these strategic goals?

- For the provision of a high-quality education to a diverse student body in the region, explain that PLTL uses, for example, "cooperative learning as well as the more social and verbal learning styles that characterize many female and diverse learners. This means that we have more female and ethnic minority students who are successful in College level math and science and who become majors and later professionals in disciplines that are not usually seen as friendly to them" (pp. 1-2).
- Provide data: Administrators need to know about "improved retention and graduation rates among students of color, [because they] will have to defend the program to University Budget Committees, Provosts, and even Trustees."
- Provide a budget in a timely manner. Budgets are developed on a regular, early cycle, so finding sources of funding on a continuing basis is critical. Administrators must make choices and may have to make trade-offs to support the PLTL program.
- Provide evidence of academic transferability. How can the program be expanded into other disciplines and demonstrate the same improvements in retention and graduation rates?
- Provide ways to consider "in kind" tradeoffs, e.g., can I call this faculty development? There may be funding that is part of another budget by demonstrating the impact of the practice on those practicing it. Payments to Peer Leaders as temporary workers might instead be given as course credit, tuition waivers, or payment from a dedicated scholarship fund.
- What message can be shared via a communication strategy, so that those in the institution are aware of the innovative practice and its benefits?

Perceived needs can drive innovation that is important to practitioners in solving context-specific problems, or that can be seen as strategic for future directions (Smith, 2012).

Peer pressure to adopt an innovation can be from other institutions, staff or students (Smith, 2012; Platt, et al., 2008).

Collecting of data allows continuing assessment and evidence that can inform practice. This should tie into an institution's data collection office, formalizing an ongoing relationship. This also allows for longitudinal studies and expanded opportunities for a scholarship of impacts.

The continuation plan for the innovation needs to be communicated, or it will disappear for a lack of visibility and support. As Smith (2012) notes, "To gain overall acceptance, there needs to be a shared vision for an innovation that is legitimised through institutional discourse" (p. 174).

Time as a factor must be considered. The embedding of new working practices does not occur quickly; gradual levels of increasing complexity take time. Penberthy and Millar (2002) tell a story of two instructors, one of whom made gradual changes to his course over many years as he tried various innovations. The successor instructor tried to implement the course with the several innovations but "constantly felt overwhelmed by the magnitude of changes he was making" (p. 262), in part because he had not internalized the changes and the reasons to incorporate them.

Conclusion

What if every course incorporated Peer-Led Team Learning, as well as other active learning strategies in instructional practice? Apkarian et al. (2021) posit that institutional leaders should consider that implementation of active learning is useful not only at the time of implementation but as the start of a change in culture in higher education. Froyd et al. (2006) suggest that such a leap of faith would solve logistical issues by not separating students into those who are and are not involved in the change. Faculty would be supported in working with Peer Leaders in their role of novice experts of both content and facilitation and would be prepared for their changing activities in knowledge learning; facilities would be designed for learning participants to face each other to discuss the course material; schedules would be structured to accommodate time for working. Formal campus leadership would set new strategic goals to provide frameworks for increased retention, graduation, and pathways to careers that serve to solve problems that are not yet known (Fadel, 2008).

Meanwhile, using the model innovation of a "Center for PLTL Education" intermediate steps by working groups of faculty, learning specialists, peer leaders, and administrators could serve as communities of practice, solving logistical, dissemination, and other problems, to

build a campus culture where all stakeholders are actively engaged and matter. Schlossberg (1989) notes that:

> Involvement creates connections between students, faculty, and staff that allow individuals, to believe in their own personal worth. This involvement also creates an awareness of our mutual relatedness and the fact that the condition of the community is not only desirable but essential to human survival. Therefore, the concern over involving students, although expediently related to satisfaction and retention, is the very process that creates community (p. 1) ….[I]nstitutions that focus on mattering and greater student involvement will be more successful in creating campuses where students are motivated to learn, where their retention is high, and ultimately, where their institutional loyalty for the short- and long-term future is ensured (p. 7).

References

Alberte, J.L., Cruz, A., Rodriguez, N., Pitzer, T. (2013a). The PLTL leader boost. *Conference Proceedings of the Peer-Led Team Learning International Society*, May 17-19, 2012, New York City College of Technology of the City University of New York. Online at https://pltlis.org/wp-content/uploads/2012%20Proceedings/PDFs/Alberte-2-2012.pdf

Alberte, J.L., Cruz, A., Rodriguez, N., Pitzer, T. (2013b). Hub-n-Spokes: A model for centralized organization of PLTL at FIU. *Conference Proceedings of the Peer-Led Team Learning International Society,* May 17-19, 2012, New York City College of Technology of the City University of New York. Online at https://pltlis.org/wp-content/uploads/2012%20Proceedings/PDFs/Alberte-2-2012.pdf

Allen, D., & Tanner, K. (2005). Infusing Active Learning into the Large-enrollment Biology Class: Seven Strategies, from the Simple to Complex. *Cell Biology Education, 4,* 4, 262–268. https://doi.org/10.1187/cbe.05-08-0113

Amaral, K.E., & Vala, M. (2009). What Teaching Teaches: Mentoring and the Performance Gains of Mentors. *Journal of Chemical Education, 86,* 5, 630. Online at https://doi.org/10.1021/ed086p630

Apkarian, N., Henderson, C., Stains, M., Raker, J., Johnson, E., & Dancy, M. (2021). What really impacts the use of active learning in undergraduate STEM education?

Results from a national survey of chemistry, mathematics, and physics instructors. *PLoS ONE 16*, 2: e0247544. https://doi.org/10.1371/journal.pone.0247544

Arendale, D. (2022). Personal communication.

Becvar, J.E., & Saupe, G.B. (2021). DIY PLTL: Funding the Program of the Leaders by the Leaders. *Advances in Peer-Led Learning,* 1, 142-154. Online at https://doi.org/10.54935/apll2021-01-12-142

Brownell, S.E., & Tanner, K.D. (2012). Barriers to Faculty Pedagogical Change: Lack of Training, Time, Incentives, and…Tensions with Professional Identity? *CBE—Life Sciences Education, 11*, 339–346. https://doi.org/10.1187/cbe.12-09-0163

Dagley, M. A., Gill, M., Saitta, E., Moore, B., Chini, J., & Li, X. (2018). Using Active Learning Strategies in Calculus to Improve Student Learning and Influence Mathematics Department Cultural Change. *Proceedings of the Interdisciplinary STEM Teaching and Learning Conference*: Vol. 2, Article 8. https://digitalcommons.georgiasouthern.edu/stem_proceedings/vol2/iss1/8

Dreyfuss, A.E. (2013). A History of Peer-Led Team Learning -1990-2012. *Conference Proceedings of the Peer-Led Team Learning International Society*, May 17-19, 2012, New York City College of Technology of the City University of New York. Online: https://pltlis.org/wp-content/uploads/Dreyfuss-History-of-PLTL-2012.pdf

Dreyfuss, A.E. (2016). Champions: The Cornerstone of PLTL Programs. *2015 Conference Proceedings of the Peer-Led Team Learning International Society*, May 28-30, 2015, University of Texas at Dallas, Richardson, Texas. Online: https://pltlis.org/wp-content/uploads/2018/03/2015-Dreyfuss.pdf

Dreyfuss, A.E. and Gosser, D.K. (2007). In their own words: Learning to be a peer leader. In Higbee, J.L., Lundell, D.B. (Eds.). *Student Standpoints about Access Programs in Higher Education,* pp. 143-157. Minneapolis, MN: Center for Research on Developmental Education and Urban Literacy, General College, University of Minnesota. Online at https://conservancy.umn.edu/bitstream/handle/11299/5361/mono6.pdf?sequence=1&isAllowed=y

Dreyfuss, A.E., Fraiman, A., Montes, M., Hudson, R., Montalvillo Ortega, F., Muniz, J. Piefke, F., Rodriguez, M., Sheila, M., Vargas, K., & Vu, N. (2021). Peer Leading Small Group Discussion During COVID-19. *Advances in Peer-Led Learning*, 1, 55-67. Online at https://doi.org/10.54935/apll2021-01-06-55

Forhan, K. (2012). When The Money Dries Up: What's a Dean to do? How you can help your Dean help you. *Peer-Led Team Learning: Sustainability*. Online: https://pltlis.org/wp-content/uploads/2012/10/SPLTLP-Forhan-When-the-Money-Dries-Up.pdf

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., & Wenderoth, M.P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111,* 8410–8415. https://doi.org/10.1073/pnas.1319030111

Froyd, J., Layne, J., & Watson, K. (2006). Issues Regarding Change in Engineering Education. *36th ASEE/IEEE Frontiers in Education Conference*, Session T1B-3.

Froyd, J.E. (2010). Evidence for the Efficacy of Research-based Instructional Strategies. Online: https://nsf.iupui.edu/media/6ec38e88-23fd-4727-8e69-92edb8142bd7/TfwwQw/CTLContent/FundedProjects/NSF/PDF/2010-Mar-31_Efficacy_of_Research-based_Instructional_Strategies.pdf (accessed on October 1, 2022).

Froyd, J.E., Henderson, C., Cole, R.S., Friedrichsen, D., Khatri, R., & Stanford, C. (2017). From Dissemination to Propagation: A New Paradigm for Education Developers. *Change: The magazine of higher learning, 49,* 4, 35-43. Online at https://doi.org/10.1080/00091383.2017.1357098

Gafney, L. (2001). Workshop Evaluation (Ch. 6). In Gosser, D.K., Cracolice, M.S., Kampmeier, J.A., Roth, V., Strozak, V.S., & Varma-Nelson, P. *Peer-Led Team Learning: A guidebook.* Upper Saddle River, NJ: Prentice Hall.

Gafney, L. (2012). Peer-Led Team Learning: Evaluation, dissemination and institutionalization. *Peer-Led Team Learning International Society*: *Evaluation*. Online at https://pltlis.org/wp-content/uploads/2012/10/Evaluation-Gafney-II-Dissemination-plus.pdf

Gafney, L., & Varma-Nelson, P. (2008). *Peer-Led Team Learning: Evaluation, Dissemination, and Institutionalization of a College Level Initiative*. Springer.

Gosser Jr., D.K., Kampmeier, J.A., & Varma-Nelson, P. (2010). Peer-Led Team Learning: 2008 James Flack Norris Award Address. *Journal of Chemical Education, 87,* 4, 374-380. https://doi.org/10.1021/ed800132w

Gosser, D.K., Cracolice, M.S., Kampmeier, J.A., Roth, V., Strozak, V.S., & Varma-Nelson, P. (2001). *Peer-Led Team Learning: A guidebook*. Prentice Hall.

Grimes, C. L., & White III, H.B. (2015). Passing the baton: Mentoring for adoption of active-learning pedagogies by research-active junior faculty. *Biochemistry and Molecular Biology Education, 43,* 5, 345-357. Online at https://doi.org/10.1002/bmb.20885

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching, 48*, 8, 952–984. Online at DOI10.1002/tea.20439.

Hickman, K., Unite, C., & Franco, M. (2021). Launching PLTL for MATH: Building on the Foundation of Supplemental Instruction. *Advances in Peer-Led Learning, 1*, 12-24. Online at https://doi.org/10.54935/apll2021-01-03-12

Hickman, K. (2016). *The effects of peer-led team learning on pass rates, academic performance, and retention of under-represented minority students in STEM courses* (Doctoral dissertation).

Jalloh, A., Grillasca, J., Abrew, A.H., Najera, J.T., & Dreyfuss, A.E. (2021). Practice based in learning theory: Peer Leaders explain their poster projects. *Advances in Peer-Led Learning, 1*, 92-98. Online at https://doi.org/10.54935/apll2021-01-08-92

Kampmeier, J.A., & Varma-Nelson, P. (2001). Institutionalizing the workshops (Ch. 5). In Gosser, D.K., Cracolice, M.S., Kampmeier, J.A., Roth, V., Strozak, V.S., & Varma-Nelson, P. *Peer-Led Team Learning: A guidebook.* Upper Saddle River, NJ: Prentice Hall.

Kezar, A.J., & Holcombe, E.M. (2020). Barriers to organizational learning in a multi-institutional initiative. *Higher Education,* 79, 1119–1138.

Lave, J., & Wenger, E. (1990). *Situated learning: legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Fadel, C. (2008). *21st Century Skills: How can you prepare students for the new Global Economy?* OECD/CERI, Paris, May. Online at https://www.oecd.org/site/educeri21st/40756908.pdf

Mauser, K., Sours, J., Banks, J. V., Newbrough, R., Janke, T., Shuck, L., Zhu, L., Ammerman, G., & Varma-Nelson, P. (2011). Cyber peer-led team learning (cPLTL): Development and Implementation. *EDUCAUSE Review Online*, 34.

National Science Foundation (1998). National Chautauqua Workshop Program: https://www.nsf.gov/pubs/1998/nsf98108/chaut.htm

National Science Foundation (2015). I-Corps for Learning (I-Corps L). https://www.nsf.gov/edu/Pubs/I-Corps_L2.pdf

Peer-Led Team Learning International Society. (2022). PLTLIS website: www.pltlis.org. Publications [tab]: https://pltlis.org/Publications.

Penberthy, D.L., & Millar, S.B. (2002). The "Hand-off" as a flawed approach to disseminating innovation: Lessons from chemistry. *Innovative Higher Education, 26,* 251-270.

Platt, P., Roth, V., & Kampmeier, J.A. (2008). Sustaining change in upper-level courses: peer-led workshops in organic chemistry and biochemistry. *Chemistry Education Research and Practice.*, *9*, 144-148. Online at DOI: 10.1039/B806230G

Preszler, R.W. (2009). Replacing lecture with peer-led workshops improves student learning. *CBE—Life Sciences Education, 8*, 182–192. Online at DOI:10.1187/cbe.09 – 01– 0002.

Quardokus Fisher, K. & Henderson, C. (2018). Department-level instructional change: Comparing prescribed versus emergent strategies. *CBE Life Sciences Education*, 17, 4. Online at https://doi.org/10.1187/cbe.17-02-0031

Rogers, E.M. (2003). *Diffusion of Innovations*, 5th ed. New York, NY, USA: Free Press.

Roth, V., Goldstein, E., & Marcus, G. (2001). *Peer-Led Team Learning: A handbook for team leaders*. Prentice Hall.

Schlossberg, N.K. (1989). Marginality and mattering: Key issues in building community. *New Directions for Student Services, 48*.

Smith, K. (2012). Lessons learnt from literature on the diffusion of innovative learning and teaching practices in higher education. *Innovations in Education and Teaching International, 49*, 2, 173–182. http://dx.doi.org/10.1080/14703297.2012.677599

Snyder, J.J., Sloane, J.D., Dunk, R.K.P., & Wiles, J. (2016). Peer-Led Team Learning helps minority students succeed. *PLOS Biology, 14,* 3, March. Online at http://dx.doi.org/10.1371/journal.pbio.1002398

Stanford, C., Cole, R., Froyd, J., Henderson, C., Friedrichsen, D., & Khatri, R. (2017). Analysis of propagation plans in NSF-funded education development projects. *Journal of Science Education Technology, 26,* 418–437. DOI 10.1007/s10956-017-9689-x

Streitwieser, B., & Light, G. (2010). When undergraduates teach undergraduates: Conceptions of and approaches to teaching in a Peer Led Team Learning intervention in the STEM disciplines--results of a two year study. *International Journal of Teaching and Learning in Higher Education, 22,* 3, 346-356. Online at https://files.eric.ed.gov/fulltext/EJ938570.pdf

Walter, E.M., Beach, A.L., Henderson, C., Williams, C.T., Ceballos-Madrigal, I. (2021). Understanding conditions for teaching innovation in postsecondary education: Development and validation of the survey of climate for instructional improvement (SCII). *International Journal of Technology in Education, 4,* 2, 166-199. https://doi.org/10.46328/ijte.46

Woodward, A., Gosser, D., & Weiner, M. (1993). Problem-solving workshops in general chemistry. *Journal of Chemical Education,* 70, 651-665.