Discussions of Engineering Education Learning Advances among Working Engineering Faculty

Prof. Byron G. Garry, South Dakota State University

BYRON GARRY is an Associate Professor and Undergraduate Program Coordinator in the Department of Construction & Operations Management in the College of Engineering at South Dakota State University. He has been a member of ASEE since 1998. As SDSU ASEE Campus Rep., his goal is to help fellow College of Engineering faculty to be reflective teachers.

Dr. Suzette R Burckhard, South Dakota State University

Dr. Burckhard earned a BS in Engineering Physics, a BS in Civil Engineering, (both from South Dakota State University) an MS in Physics. an MS in Chemical Engineering, and a PhD in Civil Engineering with emphasis in Environmental Engineering, from Kansas State University. She has been on staff at South Dakota State University since 1997 in the Civil and Environmental Engineering department where she is a professor and program coordinator for the BSCE, MSCE and PhDCE. Dr. Burckhard is a member of ASCE, ASEE, ASMR, and several other professional societies. She is a certified distance education specialist and also practices and studies active learning techniques in engineering classrooms as well as the impact of climate on hydrology, water resources and related infrastructure.

Discussions of Engineering Education Learning Advances among Working Engineering Faculty

Introduction

South Dakota State University (SDSU) has a multiple-year history of providing opportunities for faculty to engage in discussions on improving their abilities in teaching learning. Due to interest for engineering-specific topics by members of the local chapter of ASEE, an on-going series of presentations and discussions was begun in 2011 that continues through the present. Jamieson & Lohmann's[1] call to "Raise awareness of the proven principles and effective practices of teaching, learning, and educational innovation, and raise awareness of the scholarship of engineering education" has also prompted the series. The approach to the discussion series has been influenced by the changes in engineering education research that have been occurring over the past twenty years.

Over the last nine semesters there have been twenty-three discussion sessions, on topics such as teaching on-line, engaging students in the classroom, rubrics, assessment, active learning, academic quality and rigor, research-based teaching practices, ABET student objectives selection and assessment, and good teaching practices being used by young Engineering faculty on campus. This paper will discuss the goals of the series and what has been presented and discussed over the last four and a half years.

Scholarship of Teaching and Learning

There has been a large change in how engineering education is practiced and viewed in the last two decades. In the past, there was not a wide-spread, systematic approach on how to train engineering faculty to teach. As Felder and Brent[2] put it, "If you are like most university professors, you were not taught anything about how to teach in graduate school or when you began in your first faculty position. All you had to go on was how your professors taught, but nobody taught them anything about teaching either."

The lack of a well-researched, peer-reviewed, field of study on how to train university faculty to teach also extended to areas outside of the engineering field. Boyer[3] helped define the terminology of scholarship about teaching, and started a broad discussion across the country, with the publication of *Scholarship Reconsidered* in 1990. Four types of scholarship were defined:

- The Scholarship of Discovery, frontier research that increases new knowledge within a discipline
- The Scholarship of Integration, applied research that builds on and extends frontier research
- The Scholarship of Application, applied research that directly benefits society
- The Scholarship of Teaching, later renamed Scholarship of Teaching and Learning (SoTL), studies education and uses the results to improve it and involves the constant interplay of teaching and learning.

In 1994, Felder[4] wrote: "Consider the universal vision of the professor of the 90's. She does pioneering research in a critical area and brings in big bucks to support the research, including several six-figure NSF grants and 60% release time. She publishes 5-10 papers each year in the most prestigious journals in her field and is a shoo-in for the National Academy. She is a dedicated and stimulating instructor and wins teaching awards at her university and nationally. She does more than her fair share of the tedious but vital service chores that no one wants to do and does them excellently. She is mostly imaginary." In 1987 Feldman[5] examined 42 studies and concluded that "the likelihood that research productivity actually benefits teaching is extremely small…the two, for all practical purposes, are essentially unrelated."

Does that mean that engineering faculty have to make a choice between what is considered typical engineering research - Boyer's Scholarship of Discovery, Integration, or Application - or concentrate on teaching? Prince, et al. [6], argues that SoTL is the means most likely to achieve a link between teaching and typical engineering research.

At South Dakota State University, we use Boyer's fourth definition of scholarship, SoTL, to guide the course of improving education in engineering, as well as other fields outside of the professional Education field. There are several definitions to what SoTL is. Richlin[7] states a scholarly teacher investigates in the literature what has been tried to attempt to solve specific teaching problems, then selects and applies a method that has the best chance of helping students achieve a learning objective. Hutchings[8], et al., states that SoTL is, at its core, an approach to teaching that is informed by inquiry and evidence (both one's own, and that of others) about student learning. Care has to be taken that clear lines are drawn between scholarly teaching and SoTL. As Prince, et al. [6], put it, "if faculty members study innovative instructional methods, evaluate the extent to which the methods improve knowledge acquisition and skill development, apply the outcomes to their own courses, and publish relevant findings that can be used by other instructors to improve their teaching, it is reasonable to hypothesize that improved learning should result." This process may be called scholarly teaching.

SoTL can be defined[6] in relation to three types of knowledge that teachers may possess: (1) content knowledge - knowledge of the facts, principles and methods in the discipline that is being taught, (2) pedagogical knowledge - understanding of the learning process and the conditions that facilitate and hinder it, independent of the discipline in which the learning takes place, and (3) pedagogical content knowledge. This last term was coined by Shulman[9] to denote knowledge and understanding of the learning process in the context of a particular discipline. SoTL encompasses studies intended to advance pedagogical content knowledge that are made available for peer evaluation in the professional community.

Borrego, et al.[10], have traced the change in engineering education research from a reform paradigm to a research paradigm. While the reform paradigm stressed curricular change and improved pedagogy, the research paradigm emphasizes systematic investigations, rigorous methods, and convincing evidence. The reform paradigm might be called scholarly teaching and the research paradigm called SoTL.

Another explanation of SoTL comes from the National Research Council (NRC) in *Scientific Research in Education*.[11] According to this NRC report, scientific or rigorous research in education (including engineering education) should:
1. Pose significant questions that can be answered empirically
2. Link research to relevant theory
3. Use methods that permit direct investigation of the question
4. Provide a coherent and explicit chain of reasoning
5. Replicate and generalize across studies
6. Disclose research to encourage professional scrutiny and critique

The National Science Foundation has funded engineering education coalitions that have looked specifically at teaching of engineering. One was the Center for Advancement of Engineering Education (CAEE)[12]. Their final report from 2010 states that engineering faculty need to be educators who are capable of using the research on the student experience. "This involves not only preparing tomorrow's educators with conceptions of teaching that enable innovation but also understanding how today's educators make teaching decisions…. One promising approach is to work with educators who are interested in engaging in research, supporting them as they negotiate the space between their current activities and their new work in engineering education research."

Another response to Boyer's call for SoTL resulted in the National Effective Teaching Institute (NETI), which was first offered at the 1991 Annual ASEE Conference in New Orleans, Louisiana. NETI[13] has been attended by 1312 professors from 224 different schools. As reported by Felder[14], et al., NETI has motivated many of its participants to adopt or increase their use of proven teaching strategies known to correlate with improved student learning; made them more student-centered, scholarly, and reflective in their teaching practice; and induced many of them to engage in instructional development and educational scholarship. SDSU's College of Engineering has sent several faculty members to NETI over the last few years, an indicator of administration support for improving the practice of teaching in engineering.

Studies by Boice[15] show that for 95% of new faculty members it takes four to five years of trial and error to become fully productive in research and effective in teaching. Boice also found, however, that the other 5% - the "quick starters"- are effective in their first one to two years, and the actions that distinguish quick starters from their colleagues can be identified and taught. That is to say, a good faculty development program can cut several years off the normal faculty learning curve.

Hutchings[8] states that engaging in a cycle of inquiry and improvement allows teachers to identify and investigate questions that they care about in their students' learning. This allows them to implement this knowledge in the form of new curricula, new assessments and assignments, and new pedagogies, which in turn become subjects for further inquiry. This cycle of improvement becomes a powerful way for faculty to grow as professionals over time. This is work that can be done independently by engineering faculty, but having the support of other faculty encourages such work. Formal faculty development centers are playing increasingly important roles in campuses across the country; they are well

positioned to connect research in SoTL with educational issues of wider institutional concern. Faculty development centers on most campuses is commonly provided by social scientists (generally education and psychology faculty members) to campus-wide audiences. Without discipline-specific examples, it is easy for engineering faculty to dismiss program content as irrelevant to their courses[14].

ASEE has sponsored many long-term investigations into the state of engineering education over the years. The latest comes from Jamieson and Lohmann[1] in 2012, *Innovation with Impact - Creating a Culture for Scholarly and Systematic Innovation in Engineering Education*. This was a six-year study about current education practices at major engineering schools. One of their main points is that education innovation requires engineering and education expertise working in continual cycles of educational practice and research. In the Innovation[1] report, Recommendation 5 states: "Raise awareness of the proven principles and effective practices of teaching, learning, and educational innovation, and raise awareness of the scholarship of engineering education." It is with this goal in mind that the committee approaches the Best Practices in Engineering Education series.

Besterfield-Sacre[17], et al. surveyed engineering faculty & deans across the country about possible pathways for transforming engineering education. They fit the data they received into one of Henderson, et al.'s, Four Categories of Change Strategies model[18], illustrated in Figure 1. We see our efforts as falling into the area of emergent intended outcome and individual aspects changed, that is, developing reflective teachers.

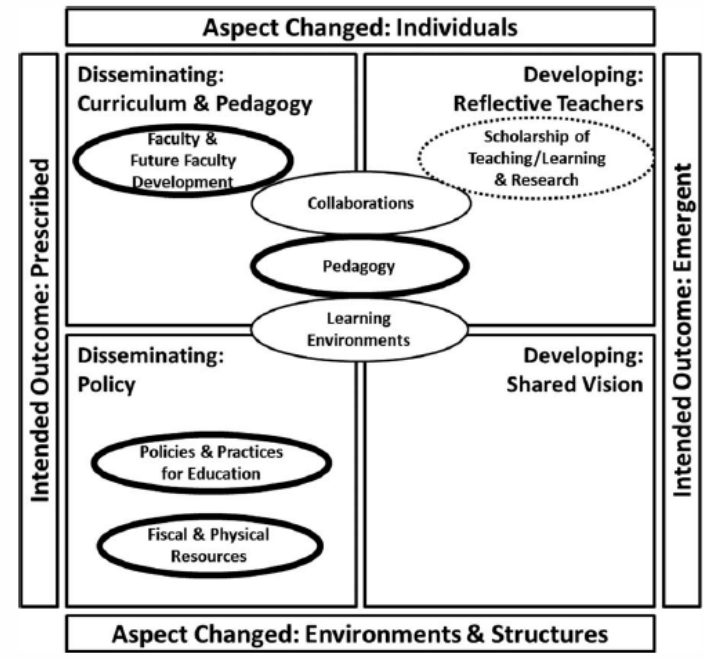

Figure 1. Mapped data from Besterfield-Sacre17, et al., based on Henderson,[18] et al., Four Categories of Change Strategies model

Best Practices in Engineering Education Sessions

Since the early 1990's there has been a series of meetings at the campus level to 'talk about teaching.' These meetings were generally very informal, and covered topics across a wide range of educational subjects. Most of the sessions were guided and led by experienced faculty from the Education or Liberal Arts fields. There was a small number of engineering faculty who would attend these meetings. In the early 2000's, a Center for the Enhancement of Teaching and Learning (CETL) was started for the entire campus by the Dean of Academic Affairs, and a half-time position was created and staffed by Andrawis, a campus Electrical Engineering professor, who retired in 2013. For several years, she used workshops and seminars too stress SoTL as an area of research for faculty, in addition to their professional field's research. From Andrawis's[19] perspective, SoTL involves the integration of teaching with the scholarship of research. She further explained that for an activity to be designated as scholarship, it should manifest at least three key characteristics, derived from Shulman[9]: it should be public, susceptible to critical review and evaluation, and accessible for exchange and use by other members of one's scholarly community.

In 2010, the CETL was emphasized even more on campus, and a regional search selected a new Director, a full-time position. Formal recognition of the Scholarship of Teaching and Learning (SoTL) on campus was seen in a 2011 brochure[20] that was published by the CETL. The brochure was written to bring focus to the difference between scholarly teaching and SoTL. Table 1 shows a summary from that brochure, which used Richlin[7] as a source.

Comparison of Scholarly Teaching + SoTL		
	Scholarly Teaching	SoTL
Anchored in literature of teaching and learning	X	X
Emphasis on documenting student learning	X	X
Teaching and learning as community property		X
Work is peer reviewed		X
Evidence of outcomes is disseminated through professional outlets		X

Table 1. SDSU CETL Definition of Scholarly Teaching vs SoTL

The work done by the CETL has brought much attention to SoTL and the subject of what is good teaching to all campus faculty, but again, few engineering faculty would attend the sponsored seminars and workshops. The general, informal, complaint was that the subjects covered were not of interest to engineering faculty, as Felder[16], et al. found.

For several years in the annual Campus ASEE meetings, attended by a maximum of ten faculty ASEE members, the discussion focused on various ways to encourage faculty to be more involved in changes being made in the field of engineering education. These initiatives were supported by the Dean of Engineering as a worthwhile thing to do, but there was no formal initiative started. There were suggestions to do mini-conferences, bring in nationally-known speakers in the area, or have campus meetings to discuss teaching topics. Little action was taken.

At the annual ASEE Campus meeting in October, 2010, a committee was formed under the title of 'ASEE Dissemination Group' and given a charge to develop an engineering-education based event, which could be a seminar, workshop, or discussion. Four committee members met to make definite plans. The committee first decided that our main considerations would be that presentations should come from College of Engineering faculty, to help ensure that the topics and discussion pertain to engineering, engineering technology, math and physics, and that all presentations should include plenty of time for questions and discussion.

The committee was renamed ASEE Best Practices in Engineering Education, and the mission of the group was defined as:

- Organize engineering education-related presentations to assist College of Engineering (COE) faculty in learning about best practices in teaching and learning
- Provide a forum or platform for our own faculty who are engaged in Scholarship of Teaching and Learning, SoTL, to present their findings locally
- Provide presentations/workshops to help faculty become better informed of what it takes to participate and be fully engaged in SoTL

The committee developed a on-line survey that was sent out to all SDSU faculty members early in the Spring 2011 semester. The questions asked were:

What types of faculty development offerings would you like to see?
Presentations, Workshops, Informal Discussions, or Webpage for posting information

If workshops/discussion series are provided by the ASEE-COE committee, what is the ideal time to hold these meetings (or events)?
Morning/lunch/afternoon and day of week – may select multiple times

What is the ideal length for a faculty development activity?
Full-day, half-day, two hours, or one hour

How often would you like to see workshops?
Four, two, or one per semester

Please select topics that interest you
A list of 44 topics were presented – may select multiple topics

Forty-seven faculty (out of approximately 100 total) responded and the consensus was that they would prefer presentations, for one-hour, over lunch-time and later in the week, for one to two times a semester. The committee further decided that food and drink would be provided, paid for by the College of Engineering Department heads in rotation. The committee sent out a follow-up email to all engineering faculty, asking for volunteers

to do presentations. Several faculty volunteered, and short presentations (under fifteen minutes), with a limited amount of discussion following, occurred in the three sessions in the first semester. There was great response to the topics and format, and further sessions were planned and continue to the present.

The amount of time needed to plan and carry-out the Best Practices sessions has been reasonable, once the process was started. For the last two academic years, the planning committee has met once or twice a semester, with emails in-between meetings used extensively to work out details, to plan on the direction of the sessions, to arrange dates for the semester, and to suggest and recruit faculty members to do presentations or lead discussions. The sessions have been strongly supported by the Dean of Engineering. Advertisement for the sessions happens at the beginning-of-the-semester College of Engineering meetings and through email to all engineering faculty. Over the nine semesters that the sessions have occurred, there has been an average of fifteen to twenty College of Engineering faculty at each session. This includes Department Heads and the Dean of Engineering, who have participated closely in the discussions. A total of twenty different SDSU faculty have presented short topics or led discussions at the sessions. The topics for the twenty-three sessions have been:

1. Teaching On-line – 2 faculty presentations - 2/24/2011
2. Engaging students in the classroom - 3/24/2011
3. Engineering Education research in your classroom/lab - a summary of presentations at ASEE Regional/Annual Meetings by SDSU faculty. Three presentations - 4/14/11
4. Problem-Based Cooperative Learning, a summary of Karl Smith's workshop presented at the Learning Cloud Academy in July, 2011 - 10/6/2011
5. Embedded Assessment: Quality Control vs. Quality Assurance - 12/1/11
6. Use of Rubrics in Assessment - 2/9/12
7. Discussion of College of Engineering collaborative project proposals for the SDSU Academic and Scholarly Excellence fund – 3/22/12
8. Collaborative project proposals – 4/12/12
9. Active Learning – 10/9/12
10. Academic Quality and Rigor – Grading. The College of Engineering portion of the campus-wide discussion – 11/13/12
11. What is Rigor and Quality? – 2/18/13
12. What is Rigor and Quality? – 3/15/13
13. Research Based Classroom Practices that Improve Student Learning – 9/17/13
14. Team-Based Learning & Immediate Feedback forms – 10/15/13
15. Curriculum planning in College of Engineering Departments – 11/19/13
16. Developing course assignments that measure specific ABET Student Outcomes – 1/28/14
17. Developing Rubrics to assess specific ABET Student Learning Outcomes – 2/25/14
18. Summary of Transforming Undergraduate Education in Engineering (TUEE). Phase I: Synthesizing and Integrating Industry Perspectives – 4/1/14
19. The Effect on Instructor Workload of Implementing Active Teaching Methods to Improve Student Enthusiasm and Performance, 9/23/14
20. NETI-2: New Ideas for Teaching, 10/6/14

21. An Idea from NETI: Handouts with Gaps, 10/14/14
22. Teaching to Multiple Learning Methods, 1/28/15
23. Accommodating Learning Styles, 2/26/15

Session Summaries

The first three sessions in Spring 2011 were arranged to be like a typical ASEE Conference meeting, with more than one presenter for the hour-long session. There was a limited amount of time left for questions after the 15-20 minute presentations. The questions that came up, such as details about the presenter handled situations with on-line classes, and how engaging students in the classroom could be handled in large classes, were answered briefly by the presenters, and other faculty felt free to add in their experiences. With the limited amount of time, little true discussion took place. The third session consisted of three presentations of papers presented at the Sectional or Annual ASEE Conference, and that provided no time for questions at all. When the Best Practices Committee reviewed the semester's sessions, it was decided that more time was needed for questions and discussions, and so only one topic would be done per session in the future, and only one or two faculty would present.

The University has been active in providing one-week-long summer workshops to groups of faculty to help them improve their teaching, mostly concerning the use of classroom technology or on-line teaching. In the summer of 2011, one workshop was attended almost exclusively by engineering faculty, and the university brought in Karl Smith for a 1½-day presentation on Cooperative Learning, among other topics. The first Best Practices session of the fall presented a Cooperative Learning exercise from Smith's workshop[22]. This exercise promoted much discussion of the learning process involved. The faculty present did not all agree on how to approach the exercise presented, and the committee believes that helped faculty see that the students in their classes might have the same experience. The next two presentations, Embedded Assessment and The Use of Rubrics, were from faculty who had presented the same information in other settings at the University previously. The topics were thought to be new to many faculty, and were considered to be mostly educational in nature. There were many questions about how to use the educational tools in specific situations. The last two sessions of the 2011-12 academic year were set aside for faculty to discuss possible topics to write proposals for the SDSU Academic and Scholarly Excellence fund. A major point that came from the discussion was that such a proposal could be used a stepping stone to be used for larger educational grant proposal. Several small groups were formed that wrote proposals for the fund dollars, but none were funded.

In the 2012-13 academic year the first session's topic was Active Learning. The presenter led the session as she would a typical class, with much free-flowing discussion of a technical topic, which appeared to be a novel approach to many of the faculty present. There were many questions asked about how this technique could be applied to other courses. For the Fall session on Grading, and the two Spring 2013 sessions on 'What is Rigor and Quality?', which followed a campus-wide set of discussions on the same subject, engineering faculty have been very open to exploring the issue via wide-

ranging discussion, with only a faculty member in front of the room guiding the debate. It is gratifying to see that some engineering faculty have become more comfortable with talking about the process of teaching and learning.

In 2013-2014, the first two sessions were chosen to help faculty consider a variety of research-based classroom practices that they could employ. Many faculty in attendance were surprised to find that many of the teaching methods they routinely use have a strong research base that shows their effectiveness. For the rest of the academic year, the prospect of ABET Accreditation visits in two years helped us choose the topics of discussion for the sessions. Discussions included how different programs do curriculum planning, an emphasis on choosing and assessing ABET-specific objectives, and a discussion of how industry influences the choice of ABET-specific objectives.

For 2014-2015, we decided to ask some of our younger faculty who have been at NETI to present some of what they have learned and are applying in their classrooms. We chose this because of a conscious decision to be encourage faculty to continue to develop as reflective teachers, as Besterfield-Sacre, et al.'s work have suggested can be a goal of our College of Engineering.

An interesting pattern has developed over the past nine semesters. As time has gone on faculty are more willing to engage in discussion about the many topics that have been presented. There have been no conclusions drawn on what is the 'best way' to engage students, provide active learning opportunities, assess student work, etc. Instead the sessions are chances for faculty to talk about teaching and ask questions of each other on specific situations that happen in their classrooms.

The sessions have attracted the attention of the full-campus CETL. They have looked at these sessions as a model for other campus departments to adopt. The Best Practices committee[23] also presented the goals and history of the sessions at the South Dakota Board of Regents system-wide Conference on Academic Quality in 2013.

In 2015, in keeping with an emphasis on scholarly teaching across the university, the campus CETL has begun a process for faculty to earn a Professional Development Certificate[24]. This certificate will be earned by faculty members who attend professional development events with a teaching and learning focus. Once a faculty member earns fifteen certification points they will be eligible for the CETL Professional Development Certificate. The goal of this program is to provide faculty all across campus with a mechanism to document their professional teaching and learning development activities and utilize them in a structured and approved manner as a demonstrator of teaching effectiveness. Attendance at sessions of the Best Practices series in the College of Engineering will be worth one certification point, and presentation at a session will be worth two points, with a maximum of five points toward the fifteen points/year required to earn the certificate.

To allow faculty to go back and look at past session presentations, we have asked for, and received permission from, faculty to allow us to post their presentations on the College of Engineering website[25].

Obstacles and Opportunities Remaining

There are obstacles to overcome in having SoTL recognized as a valid route of scholarship for engineering education faculty. Research grants bring in money, which is important, and as a relatively small engineering school we have not attempted to pursue large NSF-style education grants or attempted to participate in an engineering education coalition.

As Richlin[7] states, when a faculty member has completed a scholarly teaching process, he or she must decide whether or not to proceed with turning the findings into the scholarship of teaching. The faculty must also consider, however, whether the extra effort to write up the material, subject it to another peer review, and disseminate the resulting manuscript would be worth the time required in terms of faculty rewards. The sad truth is that many departments and institutions do not count pedagogical scholarship as part of the faculty members' scholarly production.

At SDSU, in the Professional Staff Evaluation that each faculty fills out each year, faculty are asked to set goals for next year and review their performance from the past year, in four major areas: teaching and advising; research, scholarship, and creative activity; specific service; and general service. A certain amount of effort and output is expected in all areas, depending on the kind of appointment the faculty member has. This kind of breakdown pits one kind of work against another, and it is in the faculty member's best interest to devote their energy to the area that will bring them the greatest reward. For most engineering faculty, SoTL often falls far down the list of activities.

Conclusion

From the Best Practices committee's perspective, the sessions that have taken place over the last five semesters have produced good results. Faculty members, who once would respond immediately when presented a new educational practice with "That will never work.", are now engaging in discussions by asking questions like "How did you do that?" and "Have you considered trying this?". For the future, the focus on the sessions will be to ask those faculty, who have done so, to present the work they have done to try to improve student learning. This could be in the form of scholarly teaching, where the faculty member attempted a new teaching method or process, and what the results were, good or bad; or their formal SoTL research, including research of proven methods, applying those methods, gathering verifiable results, and sharing the results through publications.

In 2011, Hutchings[8], et al., stated, "The spirit of *Scholarship Reconsidered* [3] remains highly relevant to the academy today. The message that there's an underlying scholarly dimension to different kinds of faculty work is particularly important at a time when

many colleges and universities are appointing faculty to teaching-only positions, often not on the tenure-track, increasing the danger of further separating the roles of teaching and research. We believe that the scholarship of teaching and learning is the best way for institutions to keep the interconnections between these intellectual functions alive for individual faculty." It is the goal of the committee to continue the Best Practices in Engineering Education sessions on our campus to keep SoTL, and the advances being made in good engineering education practice, in front of all working engineering faculty. It is a practice that all new Engineering faculty could encourage on their campuses, to help them in the process of improving their own teaching.

Bibliography

1. Jamieson, L.H. & Lohmann, J.R. 2012. *Innovation with Impact - Creating a Culture for Scholarly and Systematic Innovation in Engineering Education*. Washington, DC: ASEE
2. Felder, R.M., & Brent, R. 2004. *The ABC's of Engineering Education: ABET, Bloom's Taxonomy, Cooperative Learning, and so on*. Proceedings of the 2004 ASEE Annual Conference & Exposition, Salt Lake City, Utah
3. Boyer, E.L. 1990. *Scholarship Reconsidered: Priorities of the Professorate*. Carnegie Foundation for the Advancement of Teaching
4. Felder, R. 1994. The Myth of the Superhuman Professor. *Journal of Engineering Education*, 82(2): 105-110
5. Feldman, K.A. 1987. Research Productivity and Scholarly Accomplishment of College Teachers as Related to Their Instructional Effectiveness: A Review and Exploration. *Research in Higher Education* 26: 227–298
6. Prince, M.J., Felder, R.M. & Brent, R. 2007. Does Faculty Research Improve Undergraduate Teaching? An Analysis of Existing and Potential Synergies. *Journal of Engineering Education* 96(10): 283–294
7. Richlin, L. 2001. Scholarly Teaching and the Scholarship of Teaching. *New Directions for Teaching and Learning*. 86: 57-68
8. Hutchings, P., Huber, M.T., & Ciccone, A. 2011. *The Scholarship of Teaching and Learning Reconsidered: Institutional Integration and Impact***.** San Francisco: Jossey-Bass
9. Shulman, L.S. 1987. Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review* 57: 1–22
10. Borrego, M., Streveler, R., Miller, R.L. & Smith, K.A. 2008. A New Paradigm for a New Field: Communicating Representations of Engineering Education Research. *Journal of Engineering Education* 97(4): 147-162
11. National Research Council. 2002. *Scientific Research in Education.* Retrieved from http://www.ecs.org/html/educationissues/research/primer/appendixB.asp#sub1
12. Atman, C.J., Sheppard, S.D., Turns, J., Adams, R.S., Fleming, L.N., Stevens, R., Streveler, R.A., Smith, K.A., Miller, R.A., Leifer, L.J., Yasuhara, K. & Lund, D. 2010. *Enabling Engineering Student Success: The Final Report for the Center for the Advancement of Engineering Education*. Morgan & Claypool. Retrieved from http://www.engr.washington.edu/caee/
13. National Effective Teaching Institute, NETI. 2015. Retrieved from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/NETI.html
14. Felder, R.M., & Brent, R. 2010. The National Effective Teaching Institute: Assessment of Impact and Implications for Faculty Development. *Journal of Engineering Education* 99*(*4):121-134
15. Boice, R. 2000. *Advice for new faculty members: Nihil nimus*. Boston, MA: Allyn and Bacon.
16. Felder, R.M. Brent, R. & Prince, M.J. 2011. Engineering Instructional Development: Programs, Best Practices, and Recommendations. *Journal of Engineering Education* 100(1): 89–122
17. Besterfield-Sacre, M., Cox, M.F., Borrego, M., Beddoes, K. & Zhu, J. 2014. Changing Engineering Education: Views of U.S. Faculty, Chairs, and Deans. *Journal of Engineering Education* 103(2): 193-219

18. Henderson, C., Finkelstein, N., & Beach, A. 2010. Beyond dissemination in college science teaching: An introduction to four core change strategies. *Journal of College Science Teaching*, 39(5), 18–25.
19. Andrawis, M. 2009. Scholarship of Teaching and Learning (SoTL). Retrieved from http://www.sdstate.edu/engr/upload/Scholarship-of-Teaching-and-Learning-PPT.pdf
20. SDSU Center for Excellence in Teaching and Learning. 2015. Retrieved from https://insidestate.sdstate.edu/academics/general/tlc/default.aspx
21. SDSU Scholarship of Teaching and Learning brochure. 2011. Retrieved from https://sdstate.edu/academics/general/tlc/teacheffective/Power Point Presentation/SOTL Brochure FINAL.pdf
22. Smith, K. 2011. Pedagogies of Engagement: Cooperative Learning and PBL. *AL Cloud Summer Academy*. Brookings, SD
23. Garry, B., Andrawis, M. & Burckhard, S. 2013. Best Practices in Engineering Education – an On-Going Series of Discussions. *Academic Quality: Establishing Expectations and Measuring Success*. South Dakota Board of Regents Conference. Brookings, SD
24. SDSU Center for Excellence in Teaching and Learning. 2015. Retrieved from https://insidestate.sdstate.edu/academics/general/tlc/teacheffective/default.aspx
25. College of Engineering website. 2015. Retrieved from http://www.sdstate.edu/engr/asee/bestpractices.cfm