2018 ASEE Annual Conference & Exposition
June 24–27, 2018, Salt Palace Convention Center, Salt Lake City, UT
Paper ID #22021

Effects of Online Collaborative Learning with Scaffolding in Multiple STEM Courses Based on Results from Three Consecutive-Year Implementation

Prof. Wei Zheng, Jackson State University

Dr. Wei Zheng is a professor of Civil Engineering at Jackson State University. He received his Ph.D. in Civil Engineering from University of Wisconsin-Madison in 2001 and has over ten years of industrial experience. Since becoming a faculty member at JSU in 2005, he has made continuous efforts to integrate emerging technologies and cognitive skill development into engineering curriculum.

Ms. Jing Yan, Nanjing Forestry University

Dr. Yan is an assistant professor of Foreign Language Institute at Nanjing Forestry University, and she got her Ph.D. degree in Jackson State University with a constant interest in developing and implementing best practices in STEM education and language acquisition.

Dr. Justin R. Allison, Jackson State University

Justin Allison, Ph. D. is currently an Adjunct Professor in the Department of Computer Science at Jackson State University. His research interests include instructional design, educational technology, educational psychology, and distance education.

Dr. Zhenbu Zhang, Jackson State University

Dr Zhenbu Zhang is a full professor of the Department of Mathematics and Statistical Sciences at Jackson State University. Dr Zhang's research interest is Applied Mathematics including generalized Wentzel boundary value problems, analytical analysis and computer simulations of various climate models, analysis of mathematical models of malaria transmission, analysis of derivative securities.

Dr. HuiRu Shih P.E., Jackson State University

Dr. HuiRu Shih is a Professor of Technology at Jackson State University. He received his Ph.D. degree in Mechanical Engineering from the University of Missouri. Dr. Shih is a registered professional engineer in the state of Mississippi.

Exploring Effects of Online Collaborative Learning with Scaffolding in Multiple STEM Courses Based on Three-Consecutive-Year Implementation

Abstract

This paper presents results from analysis of data accumulated from implementation of scaffolding for online collaborative learning in STEM courses through a Learning Management System (LMS) in three consecutive years. Students in a variety of STEM courses were randomized into four-member teams and required to participate in collaborative learning through online discussion boards in LMS. General instructions and different levels of scaffoldings or interventions were provided online via LMS to different teams, which required students to collaboratively learn course contents and solve the assigned problems. Students' collaborative learning processes and outcomes were measured using self-report questionnaires and Concept Inventory related to course subjects. Two previously published ASEE conference papers have presented details of the proposed scaffolding and implementation procedures for online collaborative learning and reported findings based on data collected from the one-year implementation through group e-mail and LMS respectively. This paper presents results from analysis of data accumulated from implementation of the scaffolding for online collaborative learning through the online LMS – Blackboard in three consecutive years. Results show that students with both social and cognitive scaffolding have the largest knowledge gains and the most engagement in both social and cognitive processes of their collaborative learning, followed by students with only social scaffolding and students with only cognitive scaffolding in terms of building consensus in the social processes, while students without any scaffolding only outperform others in terms of externalization and elicitation of the social processes. With comparable prior learning achievement or disposition, students with scaffolding outperform those without any scaffolding in terms of their knowledge gains through online collaborative learning, indicating the beneficial impact of the scaffolding for online collaborative learning. Nevertheless, it is also found that students with higher prior learning achievement may achieve more desirable learning outcomes even without the implemented scaffolding than those with poor prior learning dispositions with the scaffolding. Finally, further research directions are also discussed.

Introduction

With the progression of information and digital technology in recent years, Learning Management Systems (LMS) have provided an effective online platform for delivery of educational courses, tracking and reporting students' learning, and sharing and exchanging information between instructors and students. While students have already started to use computer or mobile devices, particularly smart phones to access online learning materials and communicate with each other, LMS may provide a platform for them to collaboratively learn course topics through online discussion. Collaborative learning has been noted to be a more effective learning mechanism than independent individual learning, and is able to facilitate students to seek and offer explanation and help, exchange, clarify or correct their understanding, and share their views on learning contents from multiple perspectives for constructing knowledge in their learning processes [1,2]. Particularly, the social interaction for learning is the key mechanism of collaborative learning, through which the internal cognitive processes and meta-cognitive processes in learning can be provoked, exposed, and exchanged to facilitate students' learning [3,4,5].

On the other hand, students also tend to prefer collaborative learning. Koehn et al. conducted a survey revealing that students of civil/construction-engineering were in favor of collaborative learning6. The authors of this paper also surveyed STEM students majoring in engineering, chemistry, mathematics, physics, computer science, which indicated that the students recognized the effectiveness of collaborative learning, and believed that their understanding can be better improved and it was necessary to provide support to facilitate their collaborative learning.

Recognizing the importance and effectiveness of collaborative learning, more and more STEM faculty or instructors have utilized this learning mechanism in their teaching practice. For example, Soundarajan et al. adopted Peer Instruction approach to instruct engineering students to perform online collaborative learning, in which students were engaged in deep discussion with their peers and each student was provided with a specific task through e-mail with expectation for improving their students' technical and conceptual knowledge [7]. Bohorquez and Toft-Nielsen designed a problem-oriented medical electronics laboratory, where collaborative learning was adopted with the intentions of improving the expertise, self-efficacy and craftsmanship skills of biomedical engineering students. Their implementation yielded satisfactory results and demonstrated the effectiveness of their collaborative learning strategies [8]. Dong and Guo incorporated Collaborative Project-Based Learning (CPBL) into their Computer Networking course for undergraduates [9]. They indicated that the implementation of CPBL strategy was effective in facilitating their students' understanding of key concepts and improving their hands-on skills. Their students' feedback revealed that most of them were in favor of this collaborative learning method for enhancing their interest in computer networking fields.

In general, efforts of these faculty members mainly focused on the course requirements and assignments when implementing collaborative learning strategy in their courses. Nevertheless, their implementation usually did not provide systematical support or scaffolding to facilitate their students' collaborative learning processes. This may minimize the effectiveness of collaborative learning among students, because students may lack adequate the social and cognitive skills that are necessary for performing effective collaborative learning, such as the way for initiating discussion, exchanging ideas, sharing perspectives with their peers, offering explanations, and discussing at a high-level [10].

Conversely, research development in cognitive science has provided theoretical and methodological basis for effectively supporting and facilitating collaborative learning among students. Hron et al had develop the scripts for supporting students' collaborative learning and believed that the scripts would impact the collaborative learning positively when the scripts could "specify, sequence, and assign roles or activities to collaborative learners" [5,11,12,13,14]. King argued "the guided peer questioning could prompt the high-level interaction, including activities such as asking thought-provoking questions and integrating new knowledge"[15]. Therefore, King [16], Swan and Pead [17] had adopted the scaffolding through guided peer questioning prompts for supporting students' collaborative learning in their research. Empirical studies18 have demonstrated the effectiveness of such scaffolding for improving students' knowledge gains. Weiland's research findings revealed that both learning processes and learning outcomes could be influenced by different levels of scaffolding [5].

However, most of aforementioned research studies were conducted with K-12 students or liberal arts college students under experimental condition. The effects of scaffolding cyber-enabled collaborative learning have not been fully examined in authentic STEM education settings, particularly for African American students. The authors of this paper have adopted and developed the scaffolding for online collaborative learning based on the findings from cognitive research [5,11,12,13,14] and implemented it in multiple STEM learning settings at authors' institution, one of the HBCUs. In the authors' two previously published ASEE conference papers, the implementation of an instructional framework for scaffolding cyber-enabled collaborative learning in STEM courses was reported in details along with its impacts on students' learning revealed based on the data collected at that time [19, 20]. While the previously reported outcomes of students' collaborative learning were based on data collected from implementation of the presented scaffolding for online collaborative learning through group e-mails in one year and through online LMS in the other year respectively, this paper presents results from analysis of data accumulated from implementation of the scaffolding for online collaborative learning in STEM courses through the online LMS – Blackboard in three consecutive years. The newly reported results may demonstrate the more general effect of scaffolding for online collaborative learning based on a larger scale in terms of numbers of student participant than that reported previously.

Methodology

In three consecutive years from 2014 to 2016, four participating STEM instructors had repeatedly adopted the proposed scaffolding for online collaborative learning through the online LMS – Blackboard in their courses, including one chemistry course: CHEM 141- General Chemistry; one computer course: CSC 325-Operating Systems; one mathematics course: MATH 241- Calculus; and one engineering course: CIV 320-Structural Analysis, and provided data on students' collaborative learning processes and outcomes obtained from self-report questionnaires and concept inventory. In those STEM courses, students were randomly assigned into 4-member teams, and then those teams were randomly assigned into four different groups. They were assigned with relevant homework and projects and required to work collaboratively with their team members and engage in online discussions for completing assignments with their peers.

Guidelines for facilitating collaborative learning processes or scaffolding were adopted and developed based on research findings from cognitive science [5,11,12,13,14], including the scaffolding for social interaction processes through role assignment for collaborative activities and prompts for asking provoking questions in discussion, as well as the scaffolding for cognitive processes for asking specific questions related to learning subjects at hands. However, different groups of teams were provided with different levels of scaffolding based on a 2x2 factorial design of two independent variables: the scaffolding for social interaction processes and the scaffolding for cognitive processes. As a result, four different interventions were provided to student teams in four different groups. While the assignment, requirement, and grading criterion for the team collaborative learning were also developed and provided to all groups of student teams, Group A was taken as the control group without providing any scaffolding, Group B was provided with the social scaffolding only, Group C was offered with the cognitive scaffolding, and Group D was given with both social and cognitive scaffolding. Those scaffolding at different levels were provided to students through the online learning system Blackboard. Thus, students were able to respond to the given scaffolding and elaborated on them together with their team members. The details on the scaffolding can be reviewed in previously published ASEE conference papers [19,20].

The data collection was conducted through pre-test surveys, mid-way surveys, and post-test surveys. Before the intervention implementation, the pre-test - Collaborative Team Learning - was used to determine the prior knowledge on selected subjects and prior learning disposition, including concept inventory test. At the mid-point of intervention, the mid-way survey - Collaborative Learning Assignment - was adopted to investigate the learning process of each group through a self-report in Likert Scale, which is aimed to examine students' online discussion for collaborative learning. After the intervention at the end of the semester, the post-test survey - Collaborative Team Learning- was conducted on students, which aimed to examine students' learning experience, satisfaction, comments, knowledge gain on selected subjects, including the same concept inventory as the one in the pre-test.

Data from survey questionnaires were collected in form of Likert-scale with pre-test, mid-way, and post-test surveys, including Collaborative Team Learning, online collaborative experience, and satisfaction. Those data were input manually by graduate assistants into Excel files, and then were processed and analyzed by using the software SPSS. Dependent variables include knowledge gain and the interaction process, which were obtained and measured by concept inventory tests, standard instrument, and self-reported surveys. All independent and dependent variables were further divided into several sub-dimensions. Each dimension in those variables was directly quantified through self-report surveys. T-test was adopted to reveal the difference among different intervention groups.

Results from Analysis of Data Collected from Implementation in Three Consecutive Years

1. Results from Concept Inventory tests

Concept inventory test is the standard multiple-choice test for measuring understandings of major concepts in a specific subject. The students' knowledge gain is determined by the difference between the post-test scores of the concept inventory and their paired pre-test scores of the concept inventory. It is also measured by the Effect Size, which is defined as the difference between means of post-test and pre-test divided by the Std. Deviation of pre-test. Among collected concept inventory tests, there are 273 total sets of valid concept inventory tests with complete group information collected from all four courses, in which 73 sets were in Group A, 78 in Group B, 57 in Group C and 62 in Group D.

Group	Pre Test		Post Test		Growth	T	P	Effect Size
	Mean	Std. Deviation	Mean	Std. Deviation				
Group A	28.67	15.91	39.10	22.03	10.43	3.45	.001**	0.66
Group B	28.00	16.16	40.24	23.54	12.24	3.88	.000**	0.76
Group C	24.54	12.56	33.03	22.51	8.49	2.45	.017*	0.68
Group D	28.00	16.90	41.19	25.84	13.19	3.94	.000**	0.78

Table 1 Paired T-test of Pre and Post-tests of Concept Inventory between Groups

Note: Group A, n=73; Group B, n=78; Group C, n=57; Group D, n=62. Effect Size= difference between means of posttest and pretest divided by the Std. Deviation of pretest. * indicates the difference between pre and posttest is significant when $0.01<P<0.05$, ** indicates the difference between pre and posttest is very significant when $P<0.001$.

The comparisons of knowledge gains for the four student groups are demonstrated in Table 1. It is noted that students in Group A, i.e., control group, have the prior learning achievement or disposition comparable to those in Group B and Group D. Results show that the students in Group D with both social and cognitive scaffoldings have the largest knowledge gain in terms of effect size, which has statistically significant difference between pre- and post-test. Students in Group B had the second largest knowledge gain in a similar way. This may indicate that both types of scaffoldings benefit students in their collaborative learning.

However, the students in Group C had the least knowledge gain, including less knowledge gain than the students in the group without any scaffolding provided (Group A).Further examining data reveals that the students in Group C with cognitive scaffoldings only have pre-test and post-test scores significantly lower than the other three groups. This result indicates that students in Group C may have less prior learning dispositions in their learning. Those students may not outperform those in other groups in terms of their knowledge gain, even with the cognitive scaffolding. While the pre-test scores of the students in Group A are comparable to those of students in Group B and Group D, their post-test scores are less than those in Group B and Group D.

These results may indicate that the proposed scaffolding for collaborative learning have a beneficial impact in facilitating students to achieve more desirable learning outcomes. However, the impact of the bias of students' prior learning disposition may even exceed the beneficial impact of the implemented scaffolding in terms of students' subject knowledge gain, implying that students with good prior learning dispositions may achieve their learning goals with more desirable or better outcomes even without scaffolding than those with poor prior learning dispositions with scaffolding.

2. Satisfaction over the online collaborative learning and discussion forum

The results from three-year's satisfaction survey as shown in Table 2 reveal that in general, participants thought that the instruction materials for the team-based discussion were organized effectively (mean = 3.78), presented clearly (mean = 3.78) and were helpful in facilitating the exchange of ideas with team members (mean = 3.51). The participants also thought that the team-based discussion through the online system was very important and practical in helping them learn the concepts and solve problems in the course.

Table 2 Results from satisfaction survey in groups

Question	Student Group	Mean	Std. Deviation
The team-based discussion through online system is very important tool and I am interested in using them for my learning and problems solving	Group A	3.07	1.40
	Group B	**3.09**	1.33
	Group C	3.00	1.24
	Group D	3.03	1.43
The team-based discussion through online system is practical and useful in helping them learn and master important concepts in the course.	Group A	3.01	1.25
	Group B	3.16	1.14
	Group C	3.18	1.27
	Group D	**3.19**	1.20
The instruction materials for the team-based discussion through online system are organized effectively.	Group A	3.46	1.22
	Group B	3.63	1.08
	Group C	3.52	1.19
	Group D	**3.78**	1.23
The Instruction materials for the team-based discussion through online system are presented clearly.	Group A	3.59	1.27
	Group B	**3.78**	1.05
	Group C	3.67	1.18
	Group D	3.73	1.10
The instruction materials for the team-based discussion through online system help me participate in online discussion and effectively exchange ideas with other team members.	Group A	3.36	1.19
	Group B	3.43	1.14
	Group C	3.50	1.11
	Group D	**3.51**	1.22

Note: Group A, n=71; Group B, n=74; Group C, n=54; Group D, n=59.

Revealing differences among the groups for the five surveyed items shown in Table 2, the intervention group with both social and cognitive scaffolding (Group D) got higher scores than the other three groups (Groups A, B and C) in three of the survey questions, and Group B was better than the other groups in two of the survey questions. These results are consistent with results from the concept inventory, indicating that the students in Group D and Group B may perceive more benefits from and appreciate the scaffolding for online collaborative leaning.

3. Results from self-report survey for ranking usefulness of prompts

Students were also asked to rank the usefulness of prompts in the scaffolding. The frequency (or number) of the most useful top-four prompts rated by students and their percentage among the total numbers of the most useful prompts are shown in Table 3. Results in Table 3 show that "Prompts for problem solving procedures for the problem you try to solve" was considered the most useful prompt in helping participants participate in online collaborative learning (frequency percentage=24.22%). "Prompts for asking different question" was also a very useful prompt among the four prompts, which is quite close in the total frequency as the first one (frequency percentage=23.88%), which indicates that there is still a relatively high demand for social facilitation when using the tool of online discussion and asking questions.

Table 3 Rank of the usefulness of prompts by students

Prompts	Frequency as the 1st strategy	Percentage as the 1st strategy
Prompts for understanding concepts related to the problem you try to solve	66	22.84%
Prompts for problem solving procedures for the problem you try to solve	70	24.22%
Prompts for specifying roles in team discussion	51	17.65%
Prompts for asking different question	69	23.88%

Note: N=289.

Table 4 Online collaborative learning processes

Question	**Intervention Group**	**Mean**	**Std. Deviation**
Social process （Q1）	Group A	3.20	1.27
	Group B	3.11	1.19
	Group C	**3.21**	1.11
	Group D	3.18	1.12
Cognitive process（Q2）	Group A	2.97	1.12
	Group B	3.19	1.17
	Group C	**3.21**	1.10
	Group D	3.18	1.12

Note: Group A, n=70; Group B, n=74; Group C, n=52; Group D, n=57.

4. Results from Online collaborative learning process survey

The students were also asked to weight or rate eight components of their collaborative processes in two perspectives: social process and cognitive processes in the Likert 1-5 scale. The results in terms of the two main processes are shown in Table 4 and reveal that students in Group C reported the highest score in comparison to the other groups for both the social and cognitive process. While scores of the pre-test of Concept Inventory indicate that students in Group C may have the lowest prior learning achievement, the results may indicate that students with low learning achievement may feel that they need more collaborative learning and tend to involve more in both social process and cognitive process of collaborative learning processes.

Table 5 Online learning processes in eight dimensions

Question	Intervention Group	Mean	Std. Deviation
Externalization（Q3）	Group A	**4.03**	4.95
	Group B	3.20	1.22
	Group C	3.14	1.11
	Group D	3.43	1.08
Elicitation（Q4）	Group A	**4.06**	5.02
	Group B	3.35	1.21
	Group C	3.42	1.05
	Group D	3.64	1.11
Quick consensus building（Q5）	Group A	3.49	1.20
	Group B	3.28	1.10
	Group C	3.49	1.07
	Group D	**3.72**	1.15
Integration-oriented consensus building（Q6）	Group A	3.56	1.15
	Group B	3.59	1.05
	Group C	**3.64**	1.02
	Group D	3.14	1.18
Conflict-oriented consensus building（Q7）	Group A	2.99	1.21
	Group B	**3.18**	1.12
	Group C	3.13	1.09
	Group D	2.76	1.15
Construction of problem space（Q8）	Group A	2.67	1.30
	Group B	2.64	1.31
	Group C	2.61	1.30

	Group D	**3.40**	1.08
Construction of conceptual space（Q9）	Group A	3.19	1.24
	Group B	3.21	1.05
	Group C	3.34	0.96
	Group D	**3.44**	1.07
Construction of relations between conceptual and problem space（Q10）	Group A	3.25	1.19
	Group B	2.96	1.34
	Group C	3.34	1.02
	Group D	**3.49**	1.12

Note: Group A, n=70; Group B, n=74; Group C, n=52; Group D, n=57.

Table 5 show results of the survey on collaborative learning in terms of eight components of social processes and cognitive processes in the collaborative learning processes. The first five components make up the social processes and the last three components belong to the cognitive processes. The results indicate that students in Group D with both cognitive and social scaffoldings had the highest scores or advantage in half of all eight dimensions, i.e., “Quick consensus building" (mean = 3.72) in the social process, and “Construction of relations between conceptual and problem space” (mean = 3.49), “Construction of conceptual space” (mean = 3.44), "Construction of problem space" (mean = 3.40) in the cognitive processes. Students in Group B only with social scaffolding had better performance in “Conflict-oriented consensus building” (mean = 3.18). Students in Group C only with cognitive scaffolding outperform others in “Integration-oriented consensus building” (mean=3.64). Students in Control Group without any scaffolding performed better in both "Externalization" (mean = 4.03) and "Elicitation" (mean = 4.06). The results show that students in Group D performed best in most of the components, and may suggest that both cognitive and social scaffolding is effective in improving student’s learning experience, knowledge gain, and satisfaction in online collaborative learning process.

4. Conclusion

Analysis of data collected from three-consecutive-years implementation may further confirm that the implemented scaffolding demonstrated its beneficial impact on students’ knowledge gain in terms of changes in the scores of Concept Inventory tests between post-tests and pre-tests through comparison of those in the control group. Nevertheless, the academic basis or prior learning achievement of students may have played a role in the students’ learning outcomes as well. Results show that students with high prior learning dispositions may achieve more desirable or better learning outcomes even without the implemented scaffolding than those with poor prior learning achievements or dispositions with the scaffolding, implying that the adverse impact of the low prior learning achievement may even exceed the beneficial impact of the implemented scaffolding in terms of students’ subject knowledge gain.

While accumulated data indicate that the extent to which students satisfied with the intervention is above the average, they also reveal the most useful (top-four) scaffolding preferred by students, which spread equally between both social process and cognitive process, i.e., “Prompts for problem-solving procedures for the problem you try to solve”, “Prompts for asking different question", "Prompts for understanding concepts related to the problem you try to solve", and "Prompts for specifying roles in team discussion".

Examination of data related to students' involvement in the collaborative learning processes shows that students with both social and cognitive scaffolding have the most engagement in both social processes and cognitive processes, followed by those with the social scaffolding only and those with cognitive scaffolding only in terms of building consensus in the social processes, while students without any scaffolding only demonstrate their advantage in externalization and elicitation of the social processes, which only expresses rather than takes in understanding or ideals. This may indicate that the more scaffolding provided, the more meaningful engagements students could have in the collaborative learning process. These engagements of students in different groups almost align with their learning outcomes in terms of knowledge gains.

Further research may look into students' GPAs before the implementation of scaffolding for online collaborative learning and their course grade after the implementation to more accurately measure their pre and post learning achievement to overcome the influence of bias of students' prior learning achievement or disposition. It may also further explore the correlation and causal relation among their knowledge gains, prior learning achievement or disposition, and components or sub-dimensions of their online collaborative learning processes and identify the critical factors and components that can more effectively facilitate students to achieve optimal outcomes from online collaborative learning.

Acknowledgements

The authors gratefully acknowledge the support of the National Science Foundation under the grant NSF/HRD # 1332591. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors also thank participating course instructors for their collaboration and contribution in implementing the presented instructional strategies and collecting their students' learning data in their courses.

Reference

1. King, A., Staffieri, A., & Adelgais, A. (1998). Mutual peer tutoring: Effects of structuring tutorial interaction to scaffold peer learning. Journal of Educational Psychology, 90, 134-152.

2. Dunlap, J.C. (2005). Workload Reduction in Online Courses: Getting Some Shuteye. Performance Improvement, 44(5), 18-25.

3. Fischer, F., Kollar, I., Mandl, H., & Haake, J. M. (2007). Perspectives on collaboration scripts. In F. Fischer, I. Kollar, H. Mandl & J. M. Haake (Eds.), Scripting computer-supported collaborative learning: Cognitive,computational and educational perspectives (Vol. 6, pp. 1-10). New York City, NY: Springer Science+BusinessMedia, LLC.

4. Wieland, K. (2011). The Effects of Different Computer-Supported Collaboration Scripts on Students' Learning Processes and Outcome in a Simulation-Based Collaborative Learning

Environment. Florida StateUniversity
<http://diginole.lib.fsu.edu/cgi/viewcontent.cgi?article=5205&context=etd >

5. King, A. (2007). Scripting Collaborative Learning Progress: A Cognitive Perspective. In F. Fischer, I. Kollar, H. Mandl & J. M. Haake (Eds.), Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives (Vol. 6, pp. 1-10). New York City, NY: Springer Science+Business Media, LLC.

6. Koehn, E., & Koehn, J. F. (2008). Peer Assessment of Teamwork in Collaborative Learning in Construction/Civil Engineering. AC 2008-148.

7. Soundarajan, N. (2013). Work-in-progress: A novel approach to collaborative learning in engineering programs. Proceedings of the 2013 ASEE Annual Conference, Paper ID #7820, June 23 – 26, 2013, Atlanta, Georgia

8. Bohorquez, J. E., & Toft-Nielsen, J. A. (2013). Work in progress: Collaborative learning in Medical Electronics Laboratory. Retrieved January 15th, 2013 from World Wide Web: http://www.asee.org/public/conferences/20/papers/7510/view.

9. Dong, J., and H. Guo. (2013). Effective Collaborative Inquiry-based Learning in Undergraduate Computer Networking Curriculum. Proceedings of the 2013 ASEE Annual Conference, Paper ID #6113, June 23 – 26, 2013, Atlanta, Georgia

10. Weinberger, A. (2003). Scripts for computer-supported collaborative learning: Effects of social and epistemic cooperation scripts on collaborative knowledge construction. *Ludwig-Maximilians-Universität,München. < http://hal.archives-ouvertes.fr/docs/00/19/01/71/PDF/Weinberger_2003.pdf >*

11. Dansereau, D. F. (1988). Cooperative learning strategies. In C. E. Weinstein, E. T. Goetz, &

P. A. Alexander (Eds.), Learning and study strategies: Issues in assessment, instruction, and evaluation (pp. 103- 120). *New York: Academic Press.*

12. Larson, C. O., Dansereau, D. F., Goetz, E. T., & Young, M. D. (1985). Cognitive style and cooperative learning: Transfer of effects. *Paper presented at the annual meeting of the Southwest Educational Research Association, Austin, TX.*

13. Spurlin, J. E., Dansereau, D. E., Larson, C. O., & Brooks, C. W. (1984). Cooperative learning strategies in processing descriptive text: Effects of role and activity level of the learner. *Cognition and Instruction*, I, 451-463.

14. Palincsar, A, S., & Herrenkohl, L. R. (1999). Designing collaborative contexts: Lessons from three research programs. In A. O'Donnell & A. King (Eds.), *Cognitive Perspectives on Peer Learning* (pp. 151-177). Mahwah, NJ: Erlbaum.

15. King, A. (1999). Discourse patterns for mediating peer learning. In A. M. O'Donnell & A. King (Eds.), *Cognitive perspectives on peer learning* (pp. 87-115). Mahwah, NJ: Erlbaum.

16. King, A. (1992). Faciliating elaborative learning through guided student-generated questioning. *Educational Psychologist, 27*, 111-126.

17. Swan, M., & Pead, D. (2008). Professional development resources. Bowland Maths Key Stage 3, Bowland Charitable Trust. Available online in the UK at: http://www.bowlandmaths.org.uk

18. King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Educational Research Journal, 27*, 664-687.

19. Zheng, W., Cao, Y., Das, H. S., & Yin, J. (2014). Scaffolding cyber-enabled collaborative learning in engineering courses and its impacts on students' learning Process and outcomes. Retrieved from: http://www.asee.org/public/conferences/32/papers/10681/view.

20. Zheng, W., Cao, Y. (2015) Implementation and Outcomes of Scaffolding Cyber-Enabled Collaborative Learning in Multiple STEM Courses. Retrieve from: https://www.asee.org/public/conferences/56/papers/13967/view