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Scaffolding project-based learning with the project management body of knowledge (PMBOK®)

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ABSTRACT

This paper reports the results of a study of the extent to which processes and procedures from the discipline of project management can scaffold online project-based learning in a graduate-level instructional technology course, by facilitating intra-team interaction, enhancing project outcomes and promoting a positive project team experience. With one course section using tools and templates from project management and one section using only free-form text forms and instructor guidelines as project scaffolding tools, team interactions were compared via qualitative and quantitative analyses of team threaded discussions over an 8-week project lifecycle. Project outcomes were assessed by comparing project product scores using the *t*-test for independent samples, while project experience was assessed via a post-project survey using the University of Wisconsin-Madison Student Assessment of Learning Gains (SALG) questionnaire. Results indicate that the project management methodology facilitates intra-team communication and positive collaborative behavior, but is not a critical factor for final product quality. The results provide a starting point for educators and researchers seeking to assess cross-disciplinary approaches to project-based learning.

1. Introduction

As part of the process of acquiring the skills and competencies needed to become instructional design professionals, learners seek to obtain a design team experience similar to what they will encounter in the real world of work. That experience includes not only the acquisition of a strong knowledge base, but also the application of diverse social, communication and cooperation skills that today's employers expect (McLoughlin and Luca, 2002). The ability to work in teams and to communicate effectively in visual, written and oral form is deemed an essential competency by the International Board of Standards for Training, Performance and Instruction (IBSTPI, 2000). This is particularly important when design team members are dispersed across multiple locations and are meeting in a virtual environment.

One instructional strategy that enables learners to develop their collaborative skills is project-based learning. Project-based learning is grounded in general theories of knowledge such as situated learning (Lave and Wenger, 1991), which states that knowledge must be presented in an authentic context, using settings and applications that would normally involve that knowledge, and includes social interaction and collaboration to solve complex problems. However, the focus on collaboration for problem-solving has led to some confusion between project-based learning and problem-based learning. Prince and Felder (2007) note that in project-based learning, students mainly apply previously acquired knowledge and the production of some final product is the central focus of the assignment. By contrast, problem-based learning students have not previously received formal instruction in the necessary background material and the solution process is more important than the final product. Based on a qualitative review of the literature, Helle et al. (2006) deem the construction of a concrete artifact as one of the main differentiators of project-based vs. problem-based learning. Nonetheless, in postsecondary settings, particularly at the graduate level, these may not necessarily be differentiators. At the graduate level, problem-based learning can include the creation of an artifact, such as a research paper, a business case or a software application (Williams van Rooij, 2007) that earns a grade or points for the team producing that artifact, so that the final product is of critical importance.

Thomas (2000) takes a broader approach to defining project-based learning, offering five criteria that a class project must have in order to be considered an instance of project-based learning. The project must be (a) central to the curriculum, (b) focused on questions or problems that drive learners to encounter and struggle with the central concepts and principles of a discipline, (c) a constructive investigation or goal-directed process that involves inquiry, knowledge building and resolution, (d) conducive to student autonomy, choice,

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unsupervised work time, and (e) realistic, focusing on authentic challenges where the solutions have the potential to be implemented. It is this broader view that serves as the working definition of project-based learning throughout this paper.

For the instructor, one of the challenges of project-based learning is determining how much structure to apply to the course project. On the one hand, a key feature of project-based learning is learner control of the process, affording team members the opportunity to design, develop and execute their own vision of what the project processes as well as project product should be. On the other hand, it is the instructor's job to provide the appropriate amount of scaffolding to motivate learners, reduce task complexity, provide structure and reduce learner frustration (McLoughlin and Luca, 2002). Scaffolding refers to a process in which the instructor provides assistance to the student for tasks or concepts that the student is initially unable to grasp on his/her own. Once the student masters the task or concept, the instructor begins the process of "fading", or the gradual removal of the scaffolding, which allows the student to work independently (Lipscomb et al., n.d).

An additional layer of complexity is added when the class is totally online and project teams are virtual teams. Project-based learning with virtual teams not only assists with knowledge generation and application, but helps learners acquire the special skills, including an understanding of human dynamics across functional and cultural boundaries, necessary to lead and work in virtual teams in many organizations (Duarte and Tennant Snyder, 2001). As noted by Palloff and Pratt (2005), the instructor working in the online environment must be comfortable with a reasonable degree of chaos and conflict, while promoting learner self-organization and empowerment.

2. Project-based learning and project management

There is some indication that the project management Body of Knowledge® (Project Management Institute, 2004) can provide structure to virtual team projects in a variety of disciplines, while retaining the learner-driven character of project-based learning. In a study of virtual teams in an undergraduate psychology class, Chiocchio (2007) applied the project management methodology to a psychology class project on assessment, to explore how electronic information exchange concerning team coordination and tasks evolves over time for high vs. low performing virtual teams. However, since all teams in the class used the project management methodology, the study offers limited insights into the impact of the project management methodology vs. some other methodology. Leybourne (2007) notes in his review of the project management literature that there is a growing emphasis on the behavioral elements that impact the management of projects, such as conflict management and decision-making in virtual teams, while Crawford and Pollack (2007) present the case for viewing project management knowledge and practice as generic and suitable for standardization across a variety of disciplines. Nevertheless, there is little evidence about the effectiveness of the project management methodology in providing the conceptual and procedural scaffolds that would enhance online project-based learning processes and outcomes. Specifically, there is a need to explore the impact of "embedding" project management tools and templates within the multimedia/hypermedia software of the virtual learning environment as procedural scaffolds to clarify specific project-related tasks while learners are working within that virtual environment (Kao et al., 1996).

3. Context of the study: Project management and instructional design

The context of the study is a graduate certificate program that prepares students for careers that utilize current and emerging technologies to meet educational and training goals in schools, communities, government agencies and corporate settings. A core requirement of the program is a course that explores the latest innovations in distance learning technologies and environments as well as the theoretical issues central to distance learning. This 15-week core course is delivered totally online, using an asynchronous format via WebCT/Blackboard Campus Edition®, with selected synchronous sessions via the Adobe Connect® web conferencing system. The course utilizes a combination of readings, lectures, hands-on experiences, research activities, threaded discussions, reflections, and projects to help participants understand the strengths and weaknesses of current technologies as well as technology trends and directions.

As a normal part of the course work, teams of three to four students each are formed in Week 2 and remain intact throughout the duration of the course. Each team is assigned a private area on the LMS discussion board that is accessible only to the team members and the instructor and serves as the main interaction venue for documenting plans and activities for the team projects. The most critical course deliverable is the creation of a "live" fully-functioning learning/training module using one or more of the technologies explored during the course and following a basic instructional design methodology encompassing analysis, design, development, implementation, and evaluation (ADDIE) (Conrad and TrainingLinks, 2000; Dick et al., 2005; Smith and Ragan, 2005). The teams select their module topic in Week 7 and spend the remaining eight weeks working on the module for final presentation and demonstration in Week 15. Learners are deemed to have successfully demonstrated project outcomes if the module satisfies the rubric criteria published at the beginning of the course. The rubric is grounded in the National Educational Technology Standards (NETS, 2007) established by the International Society for Technology in Education and addresses the quality of team projects in the areas of (a) module design, (b) interaction and collaboration mechanisms provided in the module, (c) appropriate technologies to support the module's instructional goals/outcomes, (d) assessment(s) that align with stated objectives/outcomes, and (d) technical support information.

Scaffolding tools normally provided by the instructor include a topic overview and deliverable requirements, tips on data collection and project approach, and free-form-text project status reports assigned at specific points in the project lifecycle. Upon project completion, students complete an evaluation of the project experience using the Student Assessment of Learning Gains (SALG), a Web-based survey developed and hosted by the University of Wisconsin-Madison (Seymour, 1997). Fig. 1 illustrates the relationship between the ADDIE model and the scaffolding tools normally provided for the project.

Although the online project teams have largely been successful in completing the course projects, a review of the private team discussion boards over the past few years indicated some challenges in managing the team process, with a considerable portion of intra-team interaction more focused on organizing, scheduling, workflow, and requests for clarification than on design and development of the project product. Project Management – the application of knowledge, skills, tools and techniques to project activities to meet project requirements (Project Management Institute, 2004) – addresses team process management and as such, seemed a viable alternative to scaffolding project-based learning in the course. Consequently, the purpose of this research was to assess the extent to which processes and procedures from the discipline of project management could scaffold online project-based learning by facilitating intra-team communication, enhancing project outcomes and promoting a favorable project team experience. The following research questions were addressed:

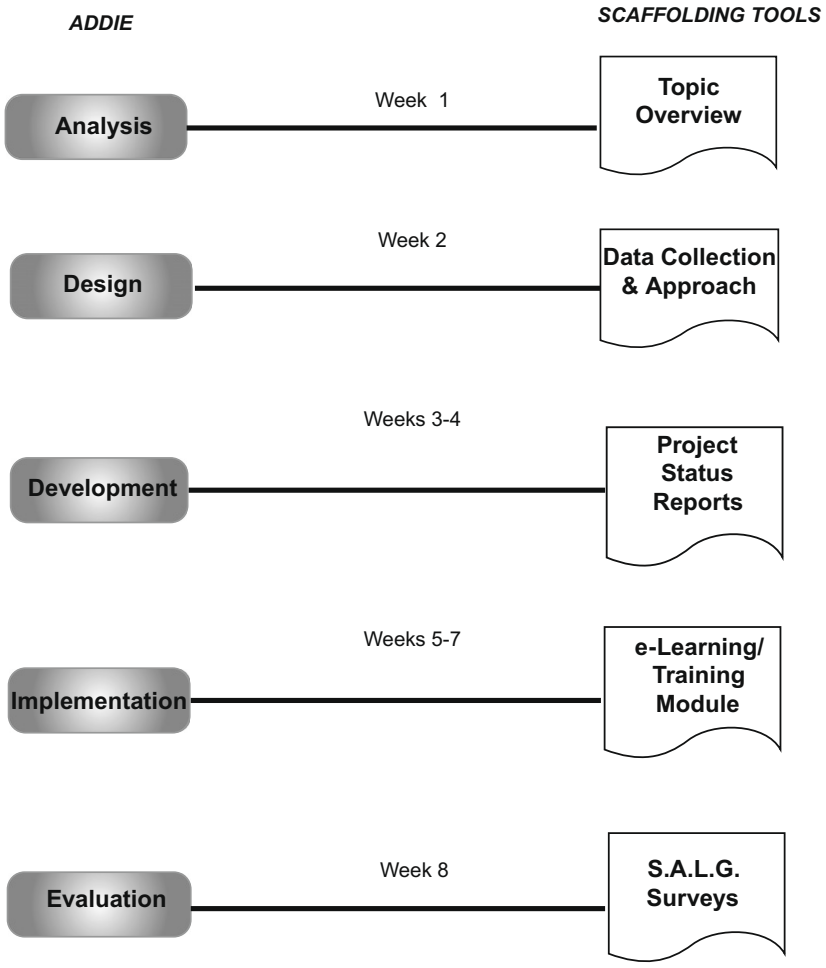

Fig. 1. Project processes (control group).

What are the differences in team interactions concerning the analysis, design, development, implementation and evaluation of the project product for teams using project management methodology and those not using that methodology over the 8-week project lifecycle?

Do teams using project management produce higher quality products than teams not using that methodology?

Do teams using project management have a more positive team experience than those not using that methodology?

4. Method

4.1. Design and procedures

The study employed a quasi-experimental design utilizing two intact sections of the same course. One course section – the Test group – used project management as scaffolding to facilitate student interactions and promote successful and timely completion of the project, along with instructor-provided tips and best practices. Test group students were introduced to the basics of project management methodology – Initiating, Planning, Executing, Monitoring and Controlling, Closing - as documented in the PMBOK® guide (Project Management Institute, 2004) and were provided with the following scaffolding (see Fig. 2):

Project charter template (Initiating): Developed collaboratively by each of the virtual teams, this document describes (a) the learning need, (b) stakeholder needs, wants, expectations, (c) the project purpose and justification, and (d) ingoing assumptions and constraints based on situational and/or organizational conditions. The scope of the project, including project deliverables, requirements and characteristics are also stated explicitly, as are the project boundaries in terms of what is included and excluded from project scope.

Work breakdown structure template (Planning): A top-down decomposition of project work into specific work "packages", this is a graphical depiction of all deliverables – including intra-team deliverables – that convert the project scope statement into tangible items. This enables the teams to better manage project scope, member time, and ensures that work doesn't slip through the cracks.

Activity list template (Planning, Executing): For each element in the Work Breakdown Structure, an activity is listed, the person responsible identified, the target due date noted and, upon activity completion, the actual completion date documented. This is an additional tool with which teams can manage scope and time.

Project status report template (Executing, Monitoring and Controlling, Closing): Unlike the open-ended text documents normally used, in which teams comment on what is (not) going well in the project, this template calls for specific data items, such as the number and percentage of tasks completed, in progress or not started; changes to scope of work, milestone dates, project risks and their likelihood of occuring as measured on a 3-point scale (high, medium, low); overall project status, and; milestones planned and accomplished.

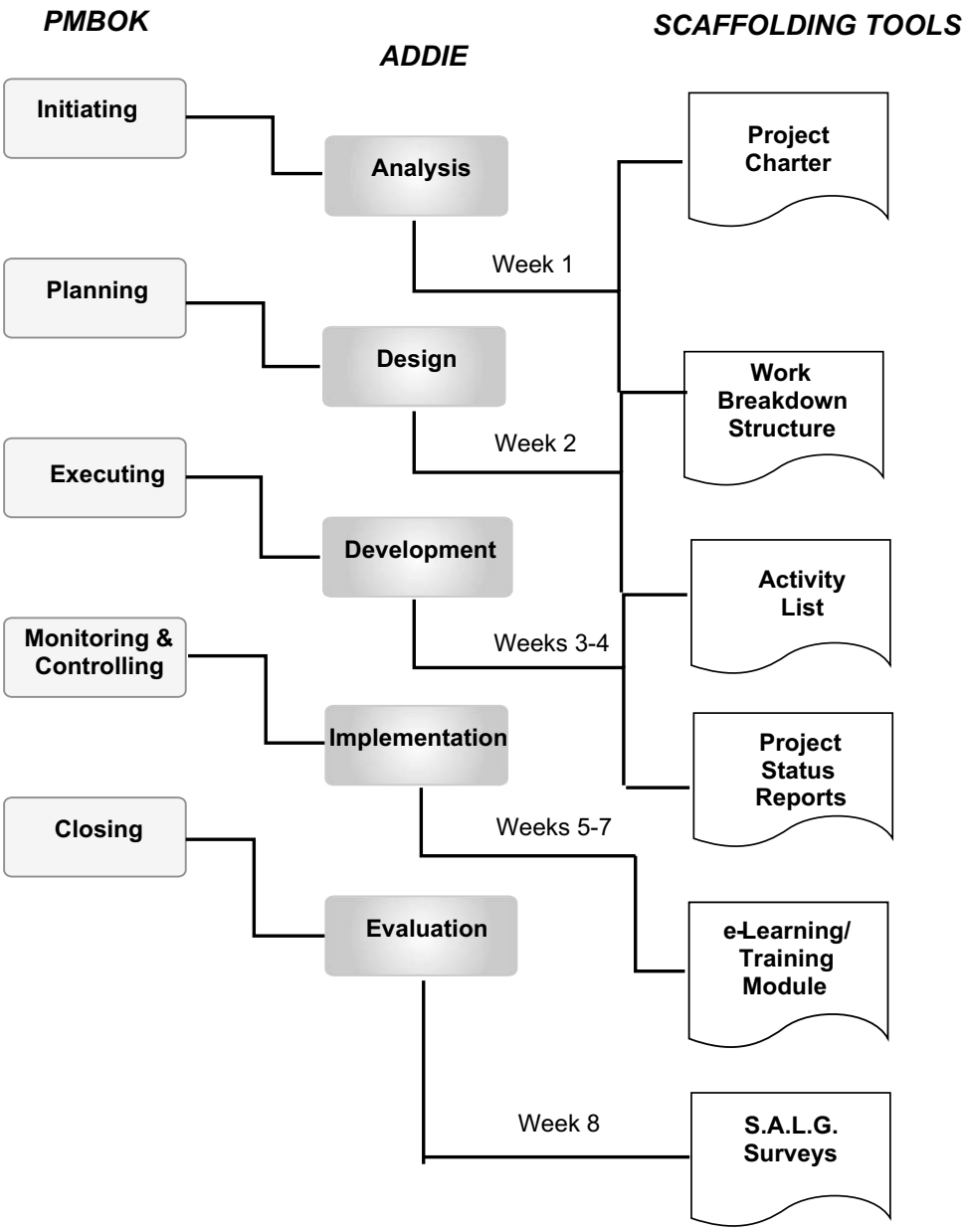

Fig. 2. Project processes (test group).

The other course section – the Control group – used only the instructor-provided tips and best practices that are normally used for the course project.

4.2. Participants

Fourteen students across the two separate course sections agreed to participate in the study, with one section randomly designated as the test group and using the project management methodology and the other section using the traditional scaffolding tools and serving as the control group. In total, four teams – one teams of three members and one of four members in the test group and one team of three members and one team of four members in the control group - were formed.

Student bios posted at the beginning of each semester indicated that test and control groups shared similar demographic characteristics in that they were (a) employed full-time in a variety of industries, (b) enrolled in the e-Learning Graduate Certificate program to advance their careers, (c) primarily male, and (d) had taken at least one online education or training course in the past two years.

4.3. Instruments and analysis

4.3.1. Team interactions

As stated in section three of this paper, teams utilized the WebCT/Blackboard discussion board to collaborate on team projects. Content analysis, the application of meaning to information through the identification of patterns in the text that the research has collected (Wilkinson and Birmingham, 2003), was used to examine the nature of team interaction during the 8-week project lifecycle. The literature offers a variety of models for the analysis of asynchronous online discussions. For example, Henri (1992) outlines five dimensions

of group interaction: Participative, interactive, social, cognitive, and metacognitive. Gunawardena et al. (1997) focus on knowledge construction as a result of group interaction, outlining a five-stage process of development necessary to the generation of new knowledge and understanding in groups in which there are areas of disagreement and/or inconsistency of beliefs. Thomas and MacGregor (2005) combine several models to create an interaction analysis model that categorizes group interactions as (a) problem solving, with a focus on course content, project modules, or knowledge/information for task completion, (b) socio-emotional, focusing on task-specific attributes that reflect personal feelings or affective support, and (c) other, referring to non-task specific attributes. This model is similar to the models of virtual team interaction offered in the management literature, particularly with regards to socio-emotional factors such as relationship building, team cohesion, trust and conflict management (Montoya-Weiss et al., 2001; Majchraz et al., 2000; Powell et al., 2004; Griffith et al., 2003).

Using Thomas and MacGregor (2005) model as a foundation, the researcher developed a model that expands the task activity category definition to analyze team online discussions in the context of instructional design and project management methodologies, while retaining the definitions of the socio-emotional and non-task related categories used in both the Thomas & MacGregor model and the virtual team literature. The coding schema is shown in Table 1.

With the assistance of a graduate student, the researcher coded and quantified the data using NVivo, a qualitative analysis software application. Each posted message was read in its entirety, then coded at the paragraph level using the coding schema.

4.3.2. Product quality

A grading rubric, distributed at the start of the course, was used to evaluate the final project deliverable. The total number of possible points for the project was 225, worth 30% of the total course grade. The rubric is grounded in the National Educational Technology Standards (NETS, 2007) established by the International Society for Technology in Education and addresses the quality of team projects in the areas of (a) module design, (b) interaction and collaboration mechanisms provided in the module, (c) appropriate technologies to support the module's instructional goals/outcomes, (d) assessment(s) that align with stated objectives/outcomes, and (d) technical support information. Projects from both the test and control teams were graded with the same rubric. Given the relatively small sample sizes, the *t*-test for independent samples was used to ascertain whether or not the test and control group project scores differ significantly.

4.3.3. Project team experience

Perceptions of the overall project experience were measured using the Student Assessment of Learning Gains (SALG), a Web-based survey developed by researchers at the University of Wisconsin-Madison. The survey questionnaire consists of a series of statements about the degree of gain that students perceive they have achieved in specific areas (Seymour, 1997) and uses a 5-point scale, where "5" means "Very much help" and "1" means "No help." Instructors can tailor the statements to their individual needs and student responses are anonymous.

Table 1
Content analysis coding schema

Categories	Types
Analysis	Topic
Comments that refer to definition of the instructional problem(s), learner characteristics, learning context, and project limitations or constraints	Students discuss project topic, rationale, stakeholders
	Scope
	Students discuss the project's deliverables and the work that is (not) required to create those deliverables, general requirements
Design	Approach
Comments that refer to learning objectives, assessment instruments, exercises, content, subject matter analysis, lesson planning and media selection	Students select strategies for gathering background data and developing appropriate instructional strategies
	Tasks
	Students determine the tasks, activities, and timelines required to complete the project
	Roles/Responsibilities
	Students determine which team members will complete which project tasks
Development	Deliverables
Comments that refer to creating and assembling the content created in the design phase.	Students complete tasks defined during the Design phase
	Testing/Prototyping
	Students integrate content with the relevant technologies, conduct pre-testing and debugging procedures and revise based on any instructor and classmate feedback given
Implementation	Monitoring/Controlling
Comments that refer to presentation and demonstration of the "live" working module	Students verify that deliverables meet stated goals, scope, product and project requirements
	Presentation
	Students determine structure of and team member roles for the "live" product demonstration
Socio-emotional	Consensus/Reinforcement
Comments that refer to task-specific attributes or issues that reflect personal feelings	Requests and responses to proposed ideas expressed in positive and/or affirming language
	Tension
	Expressions of confusion, stress or negativity about tasks or timetables
	Member Participation
	Responses to member failure to meet commitments as agreed
Other	Logistics
Comments that refer to attributes or issues that are not task-specific	Discussion of processes/procedures for facilitating virtual teamwork
	Technical
	Problems or challenges associated with the electronic environment used for virtual teamwork
	Other Socio-Emotional
	Personal feelings not associated with specific tasks or project activities

The 20-question survey was administered at the end of the course and measured the project experience on the following dimensions: (a) project approach, (b) project activities, (c) project resources, (d) project communication tools, (e) individual learner support, and (f) overall project experience. A reliability test was run on the SALG scores, yielding a Cronbach's alpha of .955, which is well above the social sciences benchmark alpha of 80%. Given the sample size, the *t*-test for independent samples was also run on the SALG scores.

5. Results

The relatively small convenience sample used in this research does not permit generalizations to any larger population of learners, nor was generalization the researcher's intent. What this research does provide are some implications for practice by offering an alternative approach to scaffolding project-based learning in an online learning environment by applying project management processes to support virtual project teams.

5.1. Team interactions

There are some clear differences between the test groups using the project management methodology and the control groups not using that methodology. First, the number of postings by the control group exceeds that of the test group at a ratio of nearly three to one, with a total of 437 message postings for the control group versus 130 for the test group. Moreover, the number of control group postings trended sharply upward from Week 2 to Week five, while test group postings remained fairly even and peaked only slightly in Week 4 (See Fig. 3).

There are also differences between test and control groups in terms of how the processes for completing the required project tasks were followed. Fig. 4 displays the percentages of interactions over the entire 8-week project lifecycle. Although all groups addressed the analysis, design, development and implementation phases of the ADDIE instructional design model, the proportion of test group interactions concerning the analysis phase are more than double that of the control groups (8.3% vs. 3.0%), with test groups focusing more of their discussions than control groups on the project topic, rationale, and stakeholders and on the scope of the project, all of which are elements of the Project Charter template provided in Week one of the project lifecycle. Further, test group comments concerning analysis and design were concentrated relatively early in the project lifecycle, while comments concerning development and implementation clustered in the last few weeks of the project lifecycle (see Fig. 5), all consistent with the sequence of scaffolding tools shown in Fig. 2. In contrast, control group interactions are dispersed across the project lifecycle irrespective of ADDIE phase. For example, comments concerning project approach – a component of the Design phase – were posted as late as Week six, when groups should have been completing the Implementation phase. Similarly, comments concerning whether deliverables meet goals and requirements – a component of the Implementation phase – were posted as early as Week 4, when groups should have been completing the Development phase.

Socio-emotional interactions accounted for more than one in five (27.8%) of all control group posted comments. The majority of the comments in this category focused on providing fellow team members with positive reinforcement for ideas or accomplished tasks and were distributed fairly evenly throughout the 8-week project lifecycle. The number of consensus/reinforcement comments tended to follow the same directional trend as the comments expressing team member confusion, stress or negativity about tasks or timetables, and comments about member failure to meet commitments as agreed.

Fewer than one in eight (12.4%) of test group posted comments concerned socio-emotional interactions, with most posted during the first two weeks of the project lifecycle. Test groups did post a greater proportion of non task-specific comments (logistics, technical, etc.) than did the control groups. Socio-emotional and non task-specific postings by week are shown in Fig. 6.

5.2. Product quality

The mean project score for the test group was 224, while the mean score for the control group was 222. A simple *t*-test of independent samples was used to determine whether or not these mean scores are statistically different from one another. The resulting *t*-value of 0.626 (df = 12, $\alpha = 0.50$) is below the 0.695 *t*-value required for significance. As such, one can argue that the project management methodology tools did not make a significantly greater contribution to product quality than did the traditional tools used as project scaffolding.

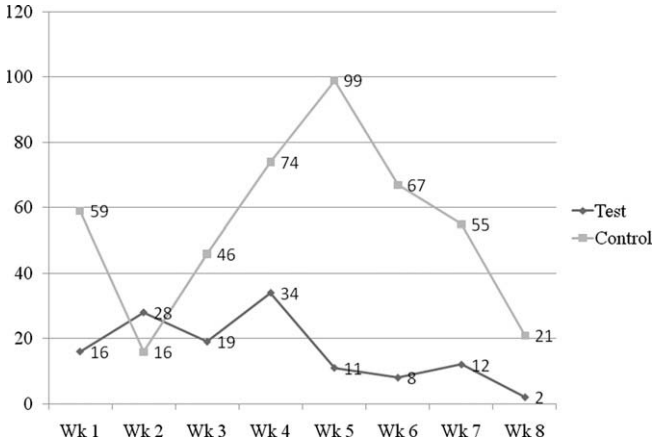

Fig. 3. Message volume: Test vs. control groups.

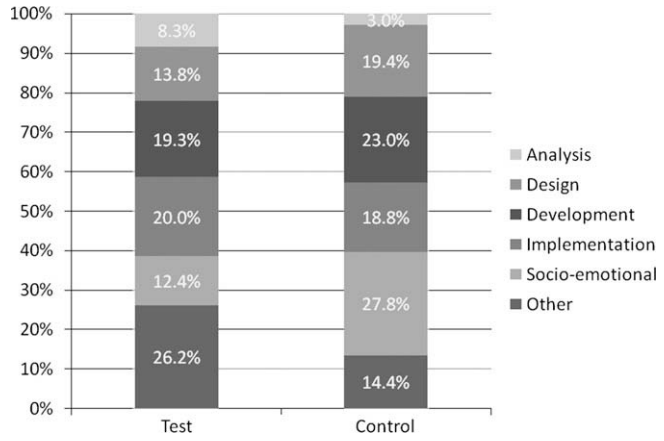

Fig. 4. Types of team interactions: Test vs. control groups.

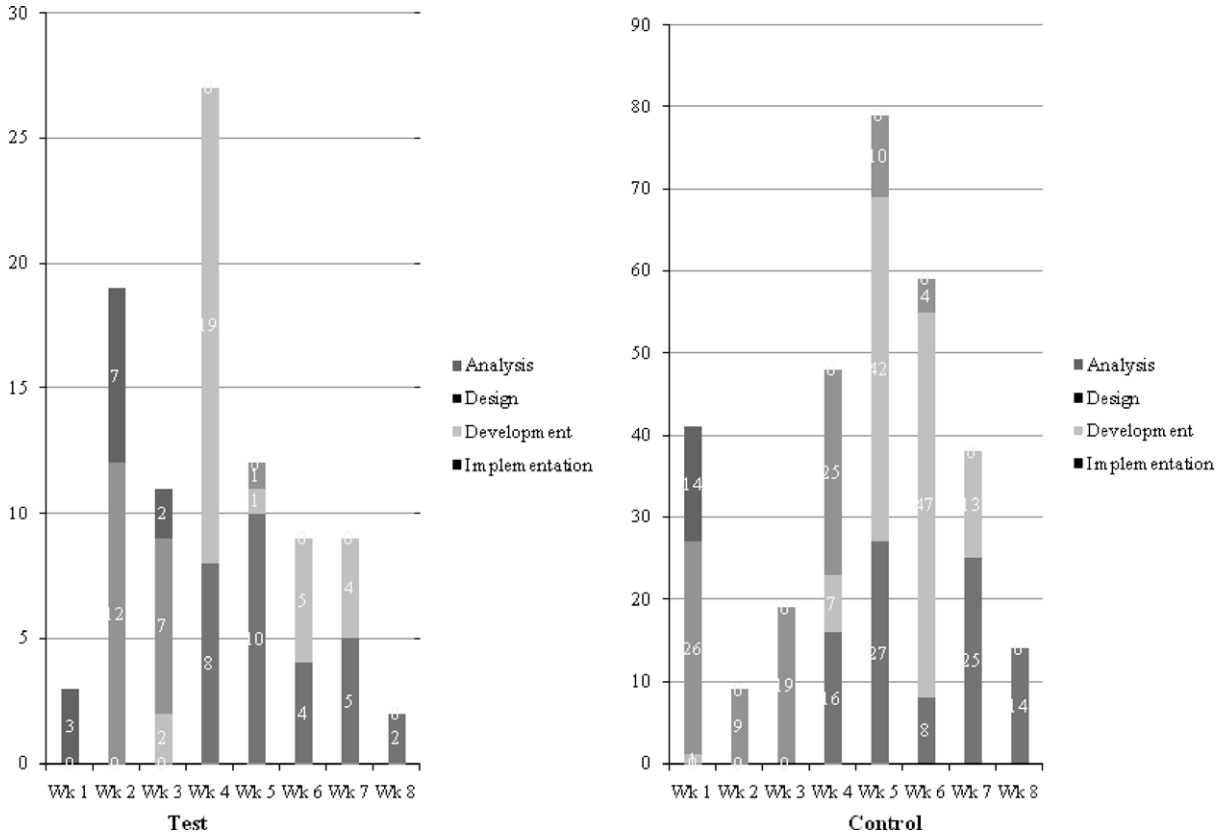

Fig. 5. Instructional design interactions: Test vs. control groups.

5.3. Project team experience

Table 2 shows that the mean SALG scores for teams using the project management methodology are higher than for teams not using that methodology on 13 of the 20 SALG attributes, particularly in the areas of project approach and project resources. However, results of the *t*-test of independent samples indicate that there is no statistically significant difference between the test and control groups on any of the SALG attributes. Thus, it appears that using the project management methodology had only a marginal impact on perceived learner benefits compared with the standard scaffolding tools used for project completion.

6. Discussion

In developing a model for the analysis of collaborative knowledge building in online discussion forums, Schrire (2006) differentiates between learner participation, defined as the number or average length of messages posted, and interaction, defined as the explicit or implicit responses to others, with the latter as being the key to what is happening in a given context. The present study affirms that

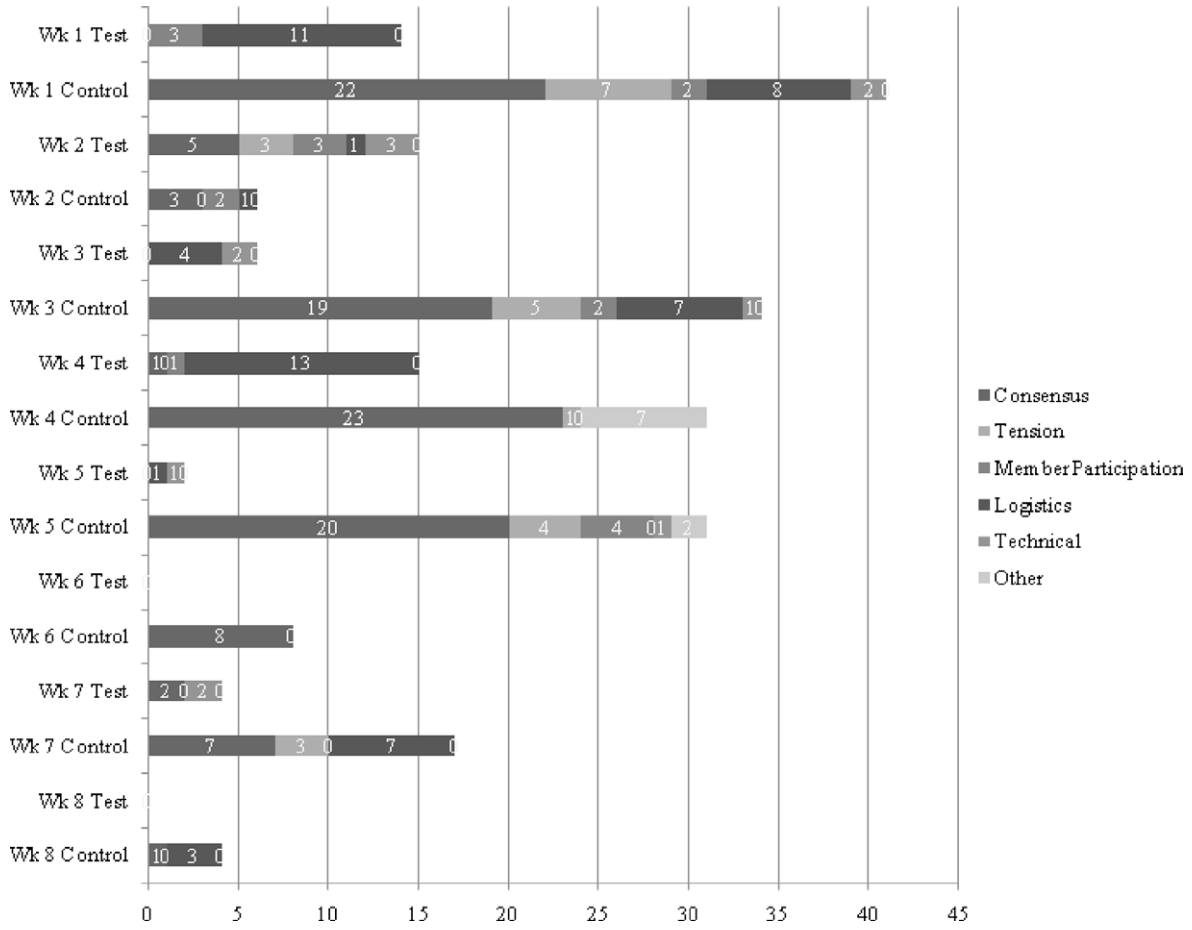

Fig. 6. Socio-emotional interactions by week: Test vs. control groups.

Table 2
Student assessment of learning gains (SALG) mean scores

Attributes	Test	Control
Project approach		
Way in which the material was approached	4.43	3.57
How project components fit together	4.29	4.00
Pace at which we worked	3.86	4.00
Project activities		
Team discussions	3.71	4.71
Deciding team member roles, responsibilities	3.43	3.86
Defining the project ourselves	4.43	3.71
Feedback from other team members	3.86	4.00
Feedback from instructor	3.71	3.14
Mental stretch required of us	3.86	3.71
Project resources		
Project requirements as defined in course syllabus	3.86	3.71
Tools/templates	4.14	4.14
Opportunity to find/evaluate resources on our own	4.14	4.00
Internet resources provided by instructor	4.00	3.14
Tips/guidelines provided by instructor	4.14	3.14
Project communication tools		
Private team discussion forum	3.86	3.86
Chat	2.43	1.86
Web conferencing	4.14	2.43
Individual learner support		
Quality of contact with team members	4.00	4.43
Quality of contact with instructor	3.71	2.43
Overall team project experience	4.14	4.00

distinction. Although the test teams had fewer postings than the control teams, the test teams used the Project Charter, Work Breakdown Structure and Activity List templates to solidify the analysis and design of their modules early on in the project lifecycle, so that subsequent interactions concerning development and implementation were more efficient and required fewer requests for clarification than did the

control group interactions. This efficiency also translated into less frustration and confusion among test team members as reflected in the postings concerning socio-emotional interactions. This would indicate that the project management methodology adds value to the team project by reducing the volume of postings required for clear, concise communication in the virtual environment.

These results are consistent with similar research in the project management literature. For example, Lee-Kelley and Sankey (2008) conducted a case study that included eleven in-depth interviews of project managers of two virtual teams – one in the UK and one in Greece - in a multinational bank project in which teams communicated primarily via asynchronous messages. One team adhered strictly to the project management methodology, while the other operated in a less structured fashion. Although both teams completed their project on time and within budget, analysis of the project manager interviews indicated that the less structured team had poor communications planning and execution. As a result, team interactions were characterized by over-communication or too many message postings, and dissonance, such as team member frustration and confusion.

A larger study (Qureshi et al., 2006) examined the asynchronous discussion boards of 21 virtual project teams from Erasmus University in The Netherlands and the City University of Hong Kong. The teams were provided with clear project instructions but no specific tools or templates as scaffolding. Content analysis of team interactions revealed challenges similar to those found by Lee-Kelley and Sankey and to those found by the researcher in the present study. Henderson (2008) explored the relationships among (a) project managers' competencies in decoding and encoding communication, (b) the satisfaction and productivity of their team members, and (c) the degree of virtuality present in the project via a Web-based survey of 564 project management practititoners. Survey results indicated a positive association between communication competencies and team satisfaction and productivity. However, geographic dispersion of the project team was negatively linked to team member satisfaction, project productivity and communication competencies. In short, the findings of the present study are in line with those of other studies that identify project management processes and procedures as facilitating intra-team communication in a virtual environment.

By contrast, project management methodology vs. traditional project scaffolding is not a critical factor in producing high-quality product outcomes or a positive overall project experience. One reason for these results could be the relatively small number ($N = 14$) of learners in the two course sections. However, the strength of the *t*-test for independent samples is its ability to detect significant differences in samples as small as 5–10 cases (Garson, 2008). Another explanation may be the fact that both test and control groups were comprised of adult professionals intent on producing a quality product regardless of the level of effort required and by the fact that some learners in both the test and control groups already had some virtual team experience in the workplace.

7. Conclusions

This research demonstrates that using processes and procedures from the project management methodology can facilitate communication among members of virtual teams of graduate-level adult learners who are already active in the workplace. The project management tools and templates used in the research are among the tools used most extensively and that receive the highest levels of organizational support in the workplace, regardless of project size or industry (Bessner and Hobbs, 2008). Project management is becoming a key strategy for managing organizational change in contemporary organizations, with corporations, government, academia and other organizations recognizing the value of common project approaches and of educated employees for the execution of projects (Kioppenborg and Opfer, 2002). Consequently, the acquisition of project management skills should be a part of project-based learning, particularly in virtual settings.

It should be noted that this research represents a snapshot of a particular context and is not generalizable to other courses, disciplines, institutions, or to other types of learners. However, it does signal several opportunities for further research. One research opportunity area would be to assess the impact of individual, personal motivators of success and performance in virtual teams. Another opportunity area would be to assess the relationship between the depth and scope of virtual team experience in the workplace and actual project outcomes. Further research would serve to enrich the literature on the effectiveness of the project management methodology as a cross-disciplinary scaffolding tool, as well as provide greater insights into factors contributing to the success of online project-based learning.

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