Capstones are integrative learning experiences near the end of a curriculum that enhance student learning through reflection, application, and synthesis of previously gained knowledge and skills. Although capstones may occur at the course, program, and institutional levels, this paper is primarily focused on the use of a single course to integrate program-level learning. The Defense & Strategic Studies (DSS) program of the United States Military Academy at West Point, NY is an interdisciplinary undergraduate major focused on producing graduates capable of strategic thinking. Since its accreditation in 2007, the DSS program has required all its graduates to take a capstone course, DS498 Colloquium in Military Affairs, that has focused on contemporary case studies relating to strategic studies. During the Academic Year 2011-12, the DSS program transitioned its capstone from a case study-based model to an experiential-based one where students work collaboratively to frame and solve a strategic problem for a real-world client. This change stems from an evolving concept of what a DSS graduate should be capable of doing. The recently revised DSS Vision Statement captures the current direction for the program and its new emphasis on working to form solutions to strategic problems:

DSS graduates are interdisciplinary and possess the substantive theoretical, historical, and policy knowledge to appropriately frame complex strategic problems, the analytical skills necessary to produce workable and innovative solutions for those problems, and the ability to effectively communicate their positions to all audiences (DSS Vision Statement, 2012).

Although the faculty has already initiated the capstone curriculum change, considerable effort remains to ensure this evolution effectively integrates program-level learning outcomes and provides a beneficial learning experience through practical application of strategic concepts. Additionally, the DSS capstone will likely provide students an opportunity to complete an individual
thesis, rather than a collaborative project, provided they take a methods course during the preceding semester. Consequently, this literature review seeks to support the evolution of the DSS capstone by identifying key characteristics of successful capstones, emphasizing their purposes, differences, effects, and best practices.

According to Theodore Wagenaar, capstones differ from regular courses because they are integrative. Within the field of sociology, he notes that introductory courses impart basic knowledge, but result in little methodological or theoretical understanding. The more substantive courses provide greater depth, but are often disconnected from other parts of the field. Honors courses and internships provide some integrative and application experience, but only reach a fraction of all students. Even some faculty members misunderstand the concept of a capstone, often conflating advanced or theoretical courses with capstone experiences. Instead, Wagenaar argues that a capstone should be an “advanced introductory” course that requires students to revisit introductory course concepts while integrating the in-depth understanding gained through courses focused on substantive knowledge, methods, and theory (Wagenaar 210-211).

But is providing an integrative experience a capstone’s only purpose? Robert Heinemann sees capstones as having two potentially competing purposes: consolidation and expansion. Heinemann argues that the consolidation, or integrative, aspect reflects a worthy “dome” that rounds out the educational experience within the discipline, but by itself serves only to further students’ knowledge within the major. Concurrently, and more importantly, a capstone course ought to serve as a “spire” from which students can expand beyond the academic environment (Heinemann 17-18). Robert Durel similarly describes capstones as a “crowning course or experience” that integrates “relatively fragmented knowledge into a unified whole,” but which should also mark a transition point, or a “rite of passage,” where students begin to look forward towards a lifetime of building on their academic experiences (Durel 223-224).
While Heinemann and Durel approach capstones from the humanities and social science disciplines of communications and sociology respectively, Awad Hanna and Kenneth Sullivan reach a similar conclusion with regard to transitioning civil engineering students from academia, where projects are more likely to be close-ended, to a professional environment, where projects are more open-ended (Hanna and Sullivan 59). An artificial problem completed solely in an academic setting limits the students’ ability to see how practical problems are actually solved within the profession, to receive answers and guidance from an experienced professional, and to interact with a physical environment related to the profession (Hanna and Sullivan 62). In this area, Todd, et al. noted criticism from professional engineers in the mid-1990s that U.S. educational institutions were not producing graduates prepared for professional engineering work (Todd, Magleby and Sorensen 165). Although their survey identified high satisfaction from students and faculty engaged in project-oriented capstones, they also noted that teamwork and partnering with industry to create valuable educational experiences needed further improvements (Todd, Magleby and Sorensen 173).

Barry Hyman identifies two shortcomings with this integrative and transitional approach to capstones within engineering education. First, students are often unprepared for the scope of capstone projects given the more limited nature of pre-capstone learning experiences. Second, most capstone experiences so closely align with the students’ graduation that they are never able to refine their products, which is an important component within the profession (Hyman 416). Hyman recommends that students engage in traditional capstone projects earlier in the curriculum so their projects can serve as a cornerstone for another course, allowing them to experience the full market analysis and refinement processes necessary for product maturity (Hyman 416-417). Russel Bruhn and Judy Camp echo the desired ends of producing professionally prepared graduates through teamwork and practical experience, but instead recommend expanding the capstone to a full academic year so students are able to produce a thoroughly tested product (Bruhn and Camp
This review explores the various effects of one- versus two-semester long capstones on product quality later.

In addition to generally addressing capstone purposes, the literature also explores in greater detail the individual student benefits of collaborative capstones focused on solving problems for real clients. Joanna Dunlap notes that “educators need to create learning environments that engage students in ways that help them develop content expertise and problem-solving, collaboration, and lifelong learning skills (Dunlap 65).” This problem- or student-centered learning model reverses the traditional paradigm of first transmitting knowledge followed by testing the student’s ability to apply that knowledge. While capstones are not meant to expressly impart new knowledge, the need to recall prior learning in such a problem-centered course requires adaptation, reasoned decision-making, critical and creative thinking, adopting holistic approaches, empathy and consideration of others, collaborating productively, and self-assessment (Dunlap 66). While students are likely to improve in these areas, one overlooked but important benefit is the increased self-efficacy students develop because they may “experience success, improving their confidence to engage in similar activities in the future, and empowering them to pursue challenges in the field (Dunlap 81).” Similarly, identity theory suggests that students only adapt to their roles as students, and therefore take a serious interest in learning, once they understand the purpose of and identify with the standard identity role of the college student as a learner (Collier 285). Evidence suggests that a capstone course exposing students to experiential learning through real-world problem-solving increases self-identification with the standard identity role of the student as a learner while preparing them to assume a new identity in the workplace (Collier 294).

Having established that the literature generally advocates for capstone experiences to be integrative with regard to prior learning and transitional with regard to post-academia endeavors, it is necessary to consider how capstones should accomplish these tasks. As previously mentioned,
two primary formats for capstones are case studies and collaborative projects. William Neumann and Marvin Woodfill compared their experiences with a traditional directed case study approach in computer science and engineering, where students worked individually and in small groups to solve a series of unrelated design problems, to a highly collaborative course, where all students focused on solving a single problem (Neumann and Woodfill 470). They found that the case study approach allowed the faculty to provide a consistent experience for all students, afforded students the opportunity to explore more complex design problems, and provided local employers with the knowledge that current graduates would be similar to previous program graduates. Comparatively, they found that while the collaborative approach resulted in better student communication skills, it also resulted in varied student outcomes as the project’s scope required compartmentalization (Neumann and Woodfill 472-473). Neumann and Woodfill note that the entire capstone course, approximately 100 students, sought to solve various components of a single problem, which likely caused their negative collaborative experience. Nevertheless, they highlight valid weaknesses associated with collaborative capstones, namely that required effort increases because more coordination is necessary and that different students can have different experiences, possibly resulting in varied student outcomes (Neumann and Woodfill 473).

A third alternative for a capstone experience is the thesis. A senior or honors thesis is an individual research project normally conducted over two semesters that focuses on integrating prior learning in the discipline with an emphasis on producing original research in the field. The chief benefit of this approach is that it prepares students for conducting independent research in graduate school (Lacey 143-144). Julie Ford and Jessica Behles find that employers in the technical communications field desire research skills but supporting undergraduate programs rarely require students to conduct independent research. They recommend a two-semester research course so that students have ample opportunity to focus on learning appropriate research methodologies, developing their own research design, and working one-on-one with a mentor to complete the
thesis (Ford and Behles 1-2). A thesis capstone, particularly an honors one, may be worthy of having initial steps, such as identifying potential topics and research advisors, occur as early as four semesters prior to graduation because an independent research project can be so time consuming. Ultimately, the amount of formal research design coursework should be discipline specific, as some fields naturally progress through research methodologies more than others (Lacey 143-144).

Having reviewed the purposes, effects, and types of capstone courses, the literature also explores some best practices. With regard to clients, Todd et al. argues that educational programs should treat prospective employers of their graduates as customers by identifying their needs and the weaknesses they perceive in recent graduates. Consequently, capstone courses ought to be specifically designed to provide experiences that “meet the needs of industry (Todd, Sorensen and Magleby, Designing a Senior Capstone Course to Satisfy Industrial Customers 92-94).” Furthermore, experiential capstone design should begin with determining the “needs, wants and values” of key stakeholders and subsequently identify concepts that meet their requirements (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 204). For capstone courses, the key stakeholders include “students, faculty, industry, [and] academic administrators... (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 204).”

Students desire content relevance, practical experience, learning skills that prospective employers value, and gaining confidence. They have limited time and consequently desire flexibility and predictability with their schedules, and always value working in teams where everyone contributes (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 204-205). Faculty members are interested in providing quality student learning experiences, but also in receiving confirmation that their peers and administrators value their efforts. Many are likewise interested in developing external funding sources to improve the quality of the capstone experience, in forming networking connections for professional benefit, and
in controlling their curriculum and schedules (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 205). Industry seeks a talent pool from which to hire, assistance in developing products and processes, and use of external research capabilities. Most importantly, “they are interested in ideas they can use now (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 205).” Administrators are primarily concerned with allocating resources to various educational programs based on defined objectives. Like students and faculty members, administrators are interested in serving the needs of their perceived client base, but are also concerned with the public reputation of the institution and limiting their programs’ liability (Todd and Magleby, Elements of a Successful Capstone Course Considering the Needs of Stakeholders 206).

In addition to addressing stakeholder needs, faculty members should consider how basic structures within the course will impact its effectiveness as a capstone experience. Team formulation is a critical aspect of collaborative capstones, but faculty members are often reluctant because of challenges associated with forming teams, managing interpersonal conflicts, and assigning individual grades in group projects (Emanuel and Worthington 229). Project teams should be comparable based on interest, academic ability, experience, personality, nationality and gender, and interpersonal history (Emanuel and Worthington 229). However, personality assessment tools, such as Myers-Briggs Type Indicator, should be used a few weeks into the capstone as team building tools rather than team formulation criteria (Emanuel and Worthington 230).

Additional structural issues revolve around group size and course length. Griffin, et al identifies a lack of consensus in the literature regarding optimal group size. Some arguments center on the idea that as group size increases so does the likelihood of “free-riding, social loafing, and conformity” while others focus on how “very small groups... lack the diversity of views and skills needed for innovation (Griffin, Griffin and Llewellyn 185).” Griffin, et al also notes that most
prior research on group size is inconclusive with regard to its effect to product quality, though it appears that group size may have minimal impact beyond five members. In their own research, Griffin, et al note students preferred the outcomes they achieved when working in groups of five to seven members rather than nine to ten (Griffin, Griffin and Llewellyn 188-189). Michael Stein found that factors such as clear project requirements from the client, a strong relationship between the client and at least one group member, and having a group member with prior project management experience were more indicative of group success than group size (Stein 4). With regard to course length, Griffin, et al found that students in a one-semester course consistently viewed their capstone experience more positively with regard to course outcomes than did those who completed a two-semester capstone. In fact, the only area where the two groups agreed was when asked whether more time would have resulted in a better product as both were generally indifferent. That clients valued the groups’ products the same regardless of course length further supports the conclusion that additional time does not necessarily yield a better product (Griffin, Griffin and Llewellyn 187-189).

A related challenge in capstone design is forming an effective student-teacher relationship when using a collaborative experience. Traditionally, this relationship is predicated on the teacher as a lecturer and the students as recipients of knowledge. In a successful capstone experience it is critical that the faculty shift towards a coaching role rather than just imparting knowledge (Taylor, Magleby and Todd 353). Taylor, et al identifies three responsibilities of a successful coach. As mentor, the coach demonstrates a willingness to provide support to the capstone team. As a mediator, the coach helps protect the team from external actors. Finally, as a manager, the coach guides the team through necessary processes to complete the project. Each team is different, so a successful coach will need to balance these responsibilities with team needs. This transition from teacher to successful coach will likely require training, prepared tools, and feedback during the project (Taylor, Magleby and Todd 355-356). On the issue of feedback, faculty members should
develop meaningful assignments throughout the capstone course that provide student information back to the faculty member to support effective learning. An example of effective feedback are group presentations to faculty because they provide “practice for professional situations” and help the group manage its work throughout the course (Paretti 500).

Another difficult task for faculty member is evaluating individuals working in a collaborative setting. Some important factors are the quality of the final product and the process used to develop it, project difficulty, peer evaluation, and instructor evaluation. Joseph Emanuel and Kenneth Worthington recommend a scoring system that adjusts the group's base performance score using various weights for these other identified factors (Emanuel and Worthington 231). Hayes et al identifies some objectives for individual grading in a collaborative project, namely that grading is fair and consistent, reflects achievement, provides feedback, is encouraging, is easy to complete, is accurate and unbiased across project types, and discourages risk managing by students. (Hayes, Lethbrdige and Port 623). They further identify several techniques for accomplishing these objectives. First, all individuals can receive the group score. While this is an easy approach for graders it can be unfair and discouraging for those who find themselves mired in a poorly performing group. Second, students can individually report their personal contributions through a portfolio or journal, but this is normally cumbersome and susceptible to student manipulation. Third, students can provide an absolute score for their peers out of 100 possible points, with the grader adjusting the final score for the individual based on their average peer score. Hayes et al use all three of these methods in conjunction with one another (Hayes, Lethbrdige and Port 624-625). Platanitis et al also recommends using transparent rubrics to evaluate projects, but specifically advances the idea of using two-dimensional rubrics based on a consolidated version of Bloom's Taxonomy of Learning Domains and demonstrated skill levels (Platanitis, Pop-Iliev and Nokleby 2-3).
This review has identified that the literature has formed a general consensus that capstones should integrate prior learning from the curriculum while also serving as a transitional vehicle that prepares students for post-academia endeavors. Capstones can be case-study based, focused on independent research, or done as collaborative projects. Focusing on the later model, such capstones provide the desired objectives of integration and transition through a problem-centered learning model that requires teachers to transition from their traditional role as lecturer to that of coach. More specifically, capstone faculty members should design their courses with multiple stakeholders in mind, take care in formulating student groups, develop assignments that help the groups through the capstone process, and create grading mechanisms that enhance the effectiveness of the capstone experience.

Bibliography


Dunlap, Joanna C. "Problem-Based Learning and Self-Efficacy: How a Capstone Course Prepares Students for a Profession." *Educational Technology Research and Development* 53.1 (2005): 65-83. Online. 21 April 2012. <http://www.springerlink.com/content/m148g5xg06n14542/>. The author conducted a nonexperimental research design to study the changes in student self-efficacy during a capstone course that utilized a Problem-Based Learning model. The author found the PBL methods resulted in greater student self-efficacy.

standard purposes and objectives of capstone courses within the field of sociology, then
described in detail how his own course accomplishes these objectives.


Todd, Robert H. and Spencer P. Magleby. "Elements of a Successful Capstone Course Considering the Needs of Stakeholders." *European Journal of Engineering Education* 30.2 (2005): 203-214. Online. 21 April 2012. <http://www.tandfonline.com/doi/abs/10.1080/03043790500087332>. The authors sought to improve capstone course design by impressing upon faculty members that there are other key stakeholders associated with these courses than just the industry clients. Specifically, course design should also consider students, teachers, and administrators.

Todd, Robert H., Carl D. Sorensen and Spencer P. Magleby. "Designing a Senior Capstone Course to Satisfy Industrial Customers." *Journal of Engineering Education* 82.2 (1993): 92-100. Online. 21 April 2012. The authors identified the changing needs of industry clients, described capstone changes designed to address these dynamic client needs, and concluded that their specific adjustments represent a good starting point for meeting these needs.
