

Bond University
Research Repository



Integrated Experiential Learning-Based Framework to Facilitate Project Planning in Civil Engineering and Construction Management Courses

Zhang, Jingxiao; Xie, Haiyan; Schmidt, Klaus; Xia, Bo; Li, Hui; Skitmore, Martin

Published in:
Journal of Professional Issues in Engineering Education and Practice

DOI:
[10.1061/\(ASCE\)EI.1943-5541.0000421](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000421)

Licence:
Other

[Link to output in Bond University research repository.](#)

Recommended citation(APA):
Zhang, J., Xie, H., Schmidt, K., Xia, B., Li, H., & Skitmore, M. (2019). Integrated Experiential Learning-Based Framework to Facilitate Project Planning in Civil Engineering and Construction Management Courses. *Journal of Professional Issues in Engineering Education and Practice*, 145(4), Article 05019005. [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000421](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000421)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

For more information, or if you believe that this document breaches copyright, please contact the Bond University research repository coordinator.

39 learning activities based on the BIM Planning Guide and test hypotheses through
40 experiments. The framework includes features of group work involvement,
41 connection with practical information, and student-centered learning. Subsequent
42 surveys of students and teachers provide further evidence of the framework merits,
43 specifically in terms of the improved formation of student cognition of BIM-based
44 project planning (90% improvement), in addition to enhanced capabilities in process
45 mapping (70% improvement), software operation (80% improvement), and
46 information exchange (100% improvement). The proposed framework sets an
47 innovative pedagogical rationale for university-based BIM education to refer to and
48 upskills undergraduate students when expanding their capabilities in information and
49 communication technology in the context of EL.

50

51 **Key-words**

52 Experiential learning, BIM capstone course, Civil Engineering and Construction
53 Management, BIM Project Planning

54

55

56 **Introduction**

57 The global higher education industry has started an active investigation into
58 educational reforms (Henderson and Trede 2017; Michelsen et al. 2017; Nabi et al.
59 2017), including the efforts to cultivate qualified BIM practitioners and popularize
60 BIM workflows. As part of the reform, there have been a variety of new pedagogical
61 models and BIM programs at universities (Jingxiao Zhang 2017; Solnosky et al. 2015;
62 Solnosky et al. 2014), such as single curriculum models, cross-curriculum models,
63 graduation design models, and BIM capstone course models. The integration of BIM
64 education into tertiary education systems has increased the demand for students to
65 acquire essential skill sets such as BIM modeling, visualization, and synergized
66 design, construction and operation activities. Introducing civil engineering and
67 construction management (CECM) students to modern BIM software systems,
68 platforms, and related processes will allow them to be more competitive and flexible
69 in a rapidly changing information technology (IT) environment (Chegu Badrinath et al.
70 2016; Ghosh et al. 2015; Zhang et al. 2016). Furthermore, visualization can enhance
71 communication among architecture, engineering, and construction (AEC) industry
72 stakeholders, and result in a better understanding of project intentions. The design,
73 construction, and operation synergies can also improve the efficiency of information
74 exchange and assist CECM students in solving 3-dimensional (3D) geometric,
75 4-dimensional (4D) scheduling, 5-dimensional (5D) cost-associated and even
76 n-dimensional (nD) tasks (Fridrich and Kubecka 2014). In principle, CECM students
77 with BIM expertise are already in high demand in the AEC industries, and the
78 realization of these BIM education initiatives requires these students to enter their
79 respective industries with hands-on experience. Hence the integration of experiential
80 learning (EL) in pedagogies of BIM classes can help prepare students and better
81 respond to industry needs.

82 This research focuses on the model designated to help learners acquire
83 practice-oriented knowledge and skills to accommodate industry needs and address
84 practical problems directly (Pikas et al. 2013). This model aligns well with the
85 concept of EL that has been largely promoted in higher education in recent years
86 (Gnaur et al. 2015; Simelane-Mnisi and Mji 2015; Wu and Hyatt 2016). Currently,
87 there is a need for pedagogical designs of EL through hands-on experience. The

88 learning environment should be supportive in applying student knowledge and
89 conceptual understanding to real-world problems or authentic situations that students
90 are expected to deal with in CECM programs. Although pedagogical practices in
91 higher education started the adoption integrated EL and capstone courses, CECM
92 education is still struggling to contextualize an essential syllabus to develop students'
93 competencies in BIM hands-on skills that specifically range across the design,
94 planning, construction, and facilities management stages. In response, this study
95 addresses the question of how to integrate actual site experiences and project
96 information of a real-world project into a CECM capstone course to enhance students'
97 BIM Project Planning competencies. There are two associated challenges with this
98 question. First, the AEC industry is organized into professional branches which do not
99 broadly collaborate enough to obtain such goals as streamlined workflows and
100 improved efficiencies (Giel and Issa 2016). Current AEC industries may not perceive
101 BIM-centered tertiary education as an integrated and collaborative venture reflecting
102 actual practices. Second, educational organizations need exemplified BIM-related
103 paradigms to ensure the knowledge transferred from the tailored BIM syllabus could
104 address a vast variety of empirical and practical real-world project management
105 challenges. BIM programs are structured in a multitude of ways (Ahn et al. 2013;
106 Andersson and Halmstad 2013; Clevenger et al. 2015; Ilozor and Kelly 2012; Zhang
107 et al. 2016). However, the majority focuses on delivering BIM software skills. To face
108 these challenges, educators should seek ways to accommodate existing experiences,
109 project planning skills, and student competencies in BIM courses.

110 Only limited research uses experience to guide the appropriate use of BIM in a
111 project (e.g., design authoring, design review, and 3D coordination), along with a
112 detailed design and documentation of the process for executing BIM throughout a
113 facility's lifecycle. To implement BIM successfully, a project team needs to perform
114 detailed and comprehensive planning. The planning strategies and site experiences
115 help students to improve competencies and become aware of the opportunities and
116 responsibilities associated with the incorporation of BIM into a well-documented
117 project workflow. Further, it supports students to follow the explicit guidelines for
118 BIM implementation in a project (e.g., design authoring, design review, and 3D
119 coordination), along with detailed design and documentation processes for executing
120 BIM throughout a facility's lifecycle. Thus, for CECM education, carrying out the

121 integration of experiential learning and BIM project execution planning provides a
122 suitable way to solve the integration problem of fragmented curricula and knowledge
123 modules in project design, construction, and operation.

124 To answer the research question, this paper builds an integrated framework using
125 Kolb's EL theory in a BIM capstone course in CECM education. Through the case
126 study of implementing the pedagogical framework, the paper explores how to use
127 existing experience to execute BIM Project Planning, how to achieve BIM uses, and
128 how student competencies can be enhanced by EL. This research the door to highlight
129 the operation process of combining EL and standard curricular instruction. Moreover,
130 it forms a pilot framework for BIM planning and training high-end BIM talents to
131 meet the industry demands. The knowledge contribution of this paper is to use Kolb's
132 EL theory to integrate BIM into a real-life capstone experience.

133

134 **Literature review**

135 *EL Theory*

136 In the EL field, Kolb's theory is widely used in engineering education (Manolis et al.
137 2013). For instructors, EL can naturally reflect the characteristics of teachers'
138 development of self-learning strategies. Following Kolb's EL theory, teachers can
139 obtain clear operational procedures in curriculum design. Learning from experience can
140 shape future learning and support university-based teachers as educators in enhancing
141 their satisfaction and achievements from working in this stimulating and provocative
142 field of teaching (Le Cornu 2016). Kolb's EL theory includes four phases: Concrete
143 experience (CE), Reflective observation (RO), Abstract conceptualization (AC), and
144 Active experimentation (AE). It emphasizes that learning is a process of transforming
145 experience, and therefore generating knowledge. The model affirms the central role
146 experience plays in the learning process.

147 In particular, in the field of CECM, site experience and real-world skills play
148 irreplaceable roles in the BIM training of virtual model and information
149 inter-operational learning (Jingxiao Zhang 2017). For example, Gümüşburun used
150 data from the Kolb Learning Style Inventory II (Demir et al. 2018) from four different
151 undergraduate programs to explore the learning styles of Turkish civil engineering
152 students (Ayalp 2015). Brown et al. (2014) developed and implemented a set of active

153 learning modules (ALMs) using Kolb's learning cycle as a conceptual framework to
154 guide and evaluate students to solve specific engineering problems (Brown et al.
155 2014). Watson et al. (2016) examined the effects of a learning-cycle-based
156 sustainability module on student conceptual understanding of sustainability at a large,
157 research-intensive university in southeastern U.S. (Watson et al. 2016). Rojas and
158 Dossick (2008) introduced an EL model to support active contextual learning, and
159 presented the "interdisciplinary research model" in the Department of Construction
160 Management at the University of Washington (Rojas and Dossick 2008). Wallin et al.
161 (Wallin et al. 2017) explored EL in a discovery-oriented environment and identified
162 three themes relating to student learning experience.

163 EL is conducive to transcend learners' ordinary experiences and limitations. It is a
164 strong driver to the attainment of not only their own goals, productivity and creativity,
165 but also their peers (because experience can be shared) (Breunig 2017). EL can also
166 contribute to the conjunction of the learner's original knowledge with the specific
167 learning context, under which the learners' inner landscape of intuition, emotions, and
168 spiritual feelings can be aligned with the outer landscape of nature (Stirling et al.
169 2017). From this perspective, the nature of BIM education aligns well with the
170 concept of EL, which can emulate a practical working environment on campus and
171 provide campus-based futuristic workforce training opportunities. A successful
172 combination of BIM education and EL can further enable student-centered learning
173 with self-learning, trial-and-error, and peer-to-peer strategies. In the proposed EL
174 pedagogical framework, potential employers can also rely on universities to cultivate
175 specific processes and skills related to projects and reduce formal in-house training
176 needs during the initial adoption of BIM. Educators need to pay attention to the three
177 themes relating to student learning experience, which are: attainment of learners'
178 goals, conjunction of knowledge with context, and student-centered learning.

179

180 ***Application BIM Project Execution Planning Guidelines in CECM education***

181 The development of BIM Project Execution Planning Guidelines (PEPG) applications
182 in CECM lags significantly behind the promotion and widespread application of BIM
183 in engineering practice. The current demand for talent with experience in BIM PEPG
184 in the AEC industries exceeds by far the output of such talent from post-secondary
185 education (Ganah and John 2017; Mathews 2013; Thomas et al. 2014; Volk et al.

186 2014). Previous work has demonstrated that, beyond curricular content, innovative
187 pedagogical approaches are also important for enhancing student learning (Cannon et
188 al. 2016; Carrick and Czekanski 2017; Othman et al. 2017). Because of the lack of
189 exploration in BIM Project Planning education research, educators and students
190 cannot obtain talent-training experience from knowledge sharing between universities.
191 They need practical and documented structures and adjustments in teaching with
192 inputs from industry experts (Hongyuan et al. 2010), who face challenges of being
193 senior BIM engineers. To some degree, a lack of university-based training forms a
194 communication barrier between industry and university. The deficiency also
195 contradicts the current BIM Project Planning university education paradigm (Cannon
196 et al. 2016; Casado et al. 2016; Helmi et al. 2016; Malik et al. 2017; Mora et al.
197 2017).

198

199 **Research Methodology**

200 ***Proposed Integration Framework***

201 Based on the features of comprehensive BIM Project Planning and its lifecycle, we
202 use a BIM capstone course as a foundation to integrate EL with BIM Project Planning
203 on a real-world project. This innovative pedagogy can greatly improve student
204 strategic understanding of BIM Project Planning throughout the lifecycle of a BIM
205 project as well the key roles of process management in BIM project management.

206

207 **Fig. 1. Proposed Framework of Designing Kolb's EL in a Capstone Course in CECM** 208 **Education**

209 Fig. 1 shows the integration process involved in the proposed framework. It
210 describes the experience resources that need to be provided to a BIM Project Planning
211 capstone course and ensures the realization of such BIM uses, as well as the created
212 learning environment, expected objectives, and planned learning outcomes. Fig. 1 also
213 illustrates how the stages of the learning cycle match the procedures of the course, and
214 the learning styles and corresponding role responsibilities involved in each stage.

215

216 ***Implementation Process***

217 The research process involved in implementing the framework is used as case study
218 (Yin 2003; Yin 2014). This includes the following intellectual contributions: (a) group
219 learning with a real-world project; (b) following the procedures of the course; (c)
220 implementing the course systematically with self-chosen BIM uses within the
221 capstone course time framework; (d) raising the awareness of the importance of BIM
222 planning; (e) information exchange in the implementation of BIM planning; and (f)
223 team cooperation. The best recommend scenario is when the project is in the early
224 planning stages for BIM implementation, so that project groups can fully discuss and
225 prepare their planning efforts.

226 For this research, the analysis unit is the BIM Project Planning capstone course,
227 and the embedded unit is the team to finish the course. This structured procedure
228 stimulates planning and directs communication in the project team during the early
229 phases of a project. After obtaining the Institutional Review Board (IRB)
230 authorization for the interviews and surveys that were conducted in this work, the
231 instructor implemented the course with the engagement of interdisciplinary fourth
232 year students from Chang'an University's School of Civil Engineering majoring in
233 CECM. This was a three-credit course. Students met twice per week. There was no
234 other course introducing BIM or modeling to the students. In spring 2017, the EL
235 framework was not implemented in the course class of 82 students, who were therefore
236 in the Non-EL Group. The students learned in the styles of traditional classroom
237 teaching and learning (Zhang et al. 2017). In spring 2018, the EL framework was
238 implemented to the capstone course class of 82 different students, who belonged to the
239 EL group. The real-world construction project was a kindergarten with one
240 underground and three above ground levels, from Taiyuan in Shanxi province. The
241 building was an irregular shaped, framed structure on a raft foundation. According to
242 the requirements of BIM project planning, there were ten BIM uses through the
243 planning and learning process, and a set of relatively authentic EL models. At the
244 same time, the implementation of BIM project planning should be supported by
245 software infrastructure.

246 Eight participating students were sampled (denoted as A to G) from both the EL
247 and Non-EL groups. These students had preliminary skills of primary 3D modeling and
248 site layout training from the traditional BIM curriculum. Four of the eight students

249 formed a team to identify the roles involved in the course, including a BIM engineer
250 and coordinator. The instructor was the project manager responsible for the overall
251 organization of the course, weekly meetings, scaffolding, explanation of questions,
252 solutions and knowledge in the course Guide. The team needed be formed at the
253 beginning of the project, with students playing the roles of technicians and supervisor
254 engineers as required by the Guide. Based on the student's career readiness and
255 willingness, the implementation of the Guide was from the contractor's perspective.

256 The following items show the process design for using Kolb's EL cycle to
257 explore this BIM PEP capstone course.

258 **(a) Analytical:** Based on the site experience, the students identified the BIM uses, and
259 finished the process mapping and information exchange of the course through
260 teamwork.

261 **(b) Experimental:** The instructor encouraged students to plan for the real project
262 management scenario to gain active and practical insights from their concrete and
263 reflective experiences.

264 **(c) Heuristic:** The instructor provided the Project Execution Planning Guidelines to
265 the students to enable them gain practice in planning skills.

266 **(d) Observative:** The instructor provided multiple site visits to students to real-world
267 projects for their concrete and reflective experience of technical and managerial
268 activities involved.

269

270 ***Evaluation***

271 A questionnaire was used to investigate the students' learning, its design being derived
272 from the typical DFS characteristics of each stage in Fig. 1. This comprises the
273 following questions:

274 For *Concrete Experience*:

275 CE#1: At my work, I feel I am bursting with energy

276 CE#2: I find the work I do to be full of meaning and purpose

277 CE#3: Time flies when I am working

278 For *Reflective Observation*:

279 RO#4: I analyze my previous experience using BIM basic principles.

280 RO#5: I make decisions by interviewing the local contractor and visiting
281 materials and equipment suppliers.

282 For *Abstract Conceptualization*:
283 AC#6: My previous thoughts about project planning have changed through BIM
284 study.
285 AC#7: My previous views about project planning have changed through BIM
286 study.
287 AC#8: My previous project planning practices have changed through BIM study.

288 For *Active Experimentation*:
289 AE#9: I apply new ideas, new skills, and new knowledge to practice.
290 AE#10: I have a new plan for my future CECM studies.

291 The Concrete Experience questions are from established questionnaires
292 concerning work engagement (Zhang and Gan 2005), while those for the Reflective
293 Observation, Abstract Conceptualization, and Active Experimentation are
294 self-compiled. All are scored on a 5-point Likert scale ranging from 1 (fully disagree) to
295 5 (fully agree).

296

297 **Empirical Case**

298 *Concrete Experience (CE)*

299 Concrete Experience (CE) is mainly from curriculum education, major curriculum's
300 real-world homework, site-based career readiness and work preparedness. During their
301 junior year, students need to learn BIM concepts, tools, applications, and stake holder
302 management concepts throughout the construction process (Fig. 1) (Jingxiao Zhang
303 2017).

304 Before the beginning of the course, the instructor and students conduct an
305 overview of the building process. At the same time, the students develop a
306 construction scheme and specifications for the learning about a real-world project.
307 One of their important tasks is the inspection of the construction project based on EL
308 objectives. During the site visit, the instructor introduced the design standards and
309 work progress, the rationale for system, and material selection as well as the
310 performance criteria involved. Their direct and comprehensive involvement
311 immediately attracted the students' attention and became the foundation of their
312 design experience. Some photographs of the site visit are shown in Fig. 2.

313

314 **Fig. 2. Site Visit before the Start of the Course**

315

316 ***Reflective Observation (RO)***

317 Without knowing the students' reflections on their previous experiences, it may be
318 difficult for the instructor to implement a course that students are able to understand
319 and conceptualize a virtual construction model. Reflection is an analytical process
320 when a learner consciously thinks. Firstly, during the site visit, the students were
321 required to combine their own experiences through the visit and put forward at least
322 three design schemes using the basic principle of BIM project planning to understand
323 BIM project planning. Secondly, the students were required to interview the local
324 contractor and visit material and equipment suppliers, to learn to make sound
325 decisions about different modes of information exchange. Thirdly, BIM is intended to
326 provide valuable EL for students to plan and control projects through its powerful 3D
327 representation, 4D simulation, and 5D cost estimation capabilities. For example, the
328 reflective observation of experiences in the design of the execution plan, as well as the
329 procurement of materials and equipment, may help students attain better planning
330 skills or a better price.

331

332 ***Abstract Conceptualization (AC)***

333 In this process, students think profoundly about the BIM project execution plan. This
334 could result in learners proposing a new idea, or modify existing concepts to explain
335 their observations (Jingxiao Zhang 2018). Abstract conceptualization in the course
336 requires students to learn from experience, and critically reflect on their knowledge,
337 attitudes, or behaviors. Then, students can improve the knowledge, attitudes and
338 behaviors in a more effective and satisfactory way. In this process, new knowledge
339 can be derived from old knowledge, and new insights can be gained from the theory
340 and practice of the course. When students implement the BIM project planning, they
341 can gradually abstract their experience and conceptualize the curriculum.

342 Abstract conceptualization in the course enables students to carry out
343 information exchange and determine the necessary infrastructure for BIM
344 implementation. The implementation includes reviewing initial BIM goals and usage
345 to ensure that the project planning is consistent. Students should consider the

346 requirements for information exchange in the implementation as well. It further
347 identifies the infrastructure needed to support processes and information exchange.
348 The instructor and students should also jointly review the final BIM project
349 implementation plan. This process includes developing weekly meeting plans and
350 making sure the instruction procedure of the course is maintained.

351 In the process of AC, students gradually understand the strategy and procedure of
352 BIM project implementation planning (e.g., how BIM projects are planned),
353 determine goals, and manage them. At the same time, it is further understood that the
354 formulation and strict implementation of planning in BIM project management are the
355 keys to the success of the BIM project, and the strategy of contrasting conceptual and
356 strategic BIM management processes with the practical skills of applied BIM
357 technology leads to a deeper BIM information exchange. In the case study, however,
358 we found that it is challenging for students to conceptualize these processes in their
359 entirety.

360

361 *Active Experimentation (AE)*

362 After the CE, RO, and AC steps, students begin the fourth cycle of AE and continue
363 their learning with information from real-world construction site visits.

364

365 BIM Use Process Mapping

366 Following the structured procedure of the course, the team started to map the BIM
367 planning process. Once the plan was created, the research team followed and
368 monitored their progress. Fig. 3 shows the overall schematic planning arrangements.

369

370 **Fig. 3.** Process Mapping of Level 1 for AE in the course

371

372 Deliverables of BIM Uses

373 The well-documented deliverables of BIM uses are intended to ensure that all parties
374 are aware of the opportunities and responsibilities associated with the incorporation of
375 BIM into the project workflow. BIM uses during the building phase include 3D
376 models, cost estimation, maintenance scheduling, 4D models, record models, 3D

377 control and planning, programming, site utilization planning, energy analysis, light
378 analysis, and collision checking. Figures 4 and 5 show the deliverables' examples of
379 BIM uses in the course. Active experimentation is expected to corroborate the use of
380 BIM technology and information management in the real-world project.

381

382 **Fig. 4.** Site Utilization Planning Deliverables

383

384 **Fig. 5.** 3D Model Deliverables

385

386 **Table 1.** Checks of the Content and Responsibility Distribution for BIM Use

387 Deliverables

388

389 The team members learn from each other by recording the information exchange
390 and file transfer. All team members are responsible for the quality control of their
391 design, their data sets, and model attributes before submitting their deliverables. The
392 file or BIM report can be submitted after confirming the quality checks. The instructor,
393 as the BIM manager, then confirms the quality of the model. At the same time,
394 students have their own scopes of BIM use deliverables, including visual, interference,
395 and standard checks. The specific checks and responsibilities assigned for active
396 experimentation are shown in Table 1.

397

398 **Results**

399 ***The Kolb Four-stage Learning Effect***

400 The questionnaire was distributed to all 82 students, 80 were collected, and 4
401 were rejected because of no answers, leaving 76 for analysis - a recovery rate of 93%.
402 The descriptive statistics elaborating the Kolb four-stage learning effect of are shown
403 in Table 2. The mean of each stage being higher than 3 indicates the learning effect is
404 good, while the significant downward trend from CE to AE¹ is expected as Kolb is a
405 spiraling learning cycle, in which each stage is a necessary condition for the later
406 stage, with the learning difficulty increasing each time constantly rising.

407

408 **Table 2.** Statistical Results of the Kolb Four-stage Learning Effect

409

¹ The probability CE>RO>AC>AE occurring by chance is .25x.33x.5=.042

410 The Kolb four-stage learning effect is ultimately reflected in the students'
411 academic attainments, which are assessed on a rising 5-point scale by teachers and
412 industrial professionals from their classroom work. Table 2 shows the correlation
413 between the Academic Attainment Scores and the Kolb four-stage learning outcomes,
414 all of which are significant at the 0.05 level, with the influence of the later stage on
415 academic attainment far exceeding the earlier stages. This is consistent with the
416 variety of the four-stage mean.

417

418 Student Responses

419 Table 3 summarizes the results of the weekly student questionnaire survey of the
420 perceived impact of incorporating the EL cycle on the course. Six questions were used
421 to investigate the learning response with the course proceeding. Generally speaking,
422 with the deepening of the course, students' attitudes become more positive. Students
423 hold different views at the beginning of the course and the final results are almost
424 converge at the end.

425

426 **Table 3.** Student Weekly Learning Response with their Course Progress

427

428 This research combines quantitative and qualitative methods together to
429 investigate the learning outcomes and student opinions, with 70 of the 82 participants
430 providing qualitative data for analysis in the form of comments on the questionnaires
431 and from the interviews. The students agreed that EL was very helpful in the course, the
432 main competencies being that, in addition to acquiring BIM skills Such as BIM
433 modeling and synergized design., they learned by working through the processes of
434 using BIM to achieve creativity and self-affirmation and graphical communication.
435 Table 3 indicates the improved formation of student cognition of BIM-based project
436 planning (90% improvement in 8-9 weeks), in addition to enhanced capabilities in
437 process mapping (70% improvement), software operation (80% improvement), and
438 information exchange (100% improvement).

439 Five themes emerged during the interviews, comprising the need for: (1) a sound
440 plan prepared by instructor; (2) an early capstone course preparation by students; (3) an
441 established implementation plan and labor division at the beginning of the course

442 assignment; (4) team members working together and strictly following the established
443 plan; and (5) learning modeling skills as early as possible, as follows.

444

445 (1) Instructors should make a sound plan for project guidance. In the BIM project
446 execution phase, the instructors or course designers should understand how
447 students learn the objects of attention, so they can plan the execution accordingly.
448 Students select the most suitable learning styles for themselves based on their own
449 previous experiences. Students can communicate with the instructors about the
450 selection of learning styles, which helps team establishment, role allocation,
451 division of labor, and plan formulation. In the implementation process, students can
452 communicate with the instructors through learning materials in real time, revise and
453 improve the learning experience, and form new knowledge and skills. As
454 participating Student A (PSA) commented,

455

456 “The drawings we found at the beginning are a bit complicated for us. They are a bit
457 problematic. It is not feasible to import the drawings directly into the BIM model, so we
458 had to replace them with simple drawings and start modeling again. This not only
459 wasted a lot of time, but also lessened our enthusiasm toward the course. Therefore, the
460 drawings must be correct and should not be too complicated. In the early stage of the
461 implementation of the BIM project, we needed to have more communication with the
462 instructors. The instructors should understand how we learn to follow the BIM project
463 target.”

464

465 Similarly, PSB commented that,

466

467 “Using the cloud functions after the completion of reinforcement and civil
468 engineering modeling, we can check the rationality of the models. There are
469 hundreds of error messages in the inspection after the initial model is
470 completed. We need to be very patient to correct the errors in this part,
471 especially to correct the errors where the component properties are irrational.
472 It is very possible to gain knowledge from this process. Only the team leader
473 and one member of the team are authorized to access the cloud functions
474 [access to project information] in each group. It would be better if we all

475 could have access. There are few subjects about building structures in the
476 undergraduate courses and the coverage is narrow. I would like to study more
477 in that area. Also, some missing parts (in the model) cannot be checked
478 automatically. For example, if there are doors and windows on the drawings
479 but missed in the model, the software cannot check them. Therefore, we must
480 be careful with the modeling and not to omit them.”

481

482 (2) Students should complete the preparation as soon as possible. After setting up the
483 tasks of the course, they should familiarize themselves with the BIM
484 implementation plan prior to the start of the semester. Meanwhile, they should
485 understand the BIM execution planning process and learn the operation of the BIM
486 software, including the modeling and BIM application processes. They can also
487 make use of the opportunities of internship practice before the final semester to
488 prepare a few sets of drawings that are suitable for modeling. These drawings
489 usually include frame or shear-wall structures, with the overall elevations being not
490 too high - usually below ten-stories. It is acceptable to have the drawings of the
491 buildings with many standard levels. As PSB commented,

492

493 “The other BIM course design teams had already started a phase of modeling
494 in November 2016. In addition, they seemed to have acquired BIM
495 knowledge and software during their college days very well. Some teams
496 completed the modeling stage by the end of December. During the winter
497 break, they studied stage two of BIM applications from January to March. At
498 the end of March, they submitted the second-phase modeling results. From
499 April to May, they basically executed the application and improvement of
500 various knowledge points according to the class schedule. In contrast, our
501 team couldn’t decide on the topic of course design until the end of last
502 semester. Some software instructions were in English. We had to translate
503 them into Chinese, which we did in the winter break. At the beginning of this
504 semester, we undertook our graduation internships for more than a month,
505 which delayed the start of the BIM design and modeling. When we were
506 finally ready for the course, it was already the end of April, resulting in
507 insufficient completion time and a hasty process. The preparation time

508 greatly affects the quality of the completed process. The more complete the
509 preparation, the better the result of the assignment.”

510

511 (3) At the beginning of the course, students must determine a complete set of
512 implementation-plans and division of labor. The plans should be completed before
513 the start of BIM design and modeling through a development meeting, and
514 according to the abilities of the individual team members. The division of tasks and
515 arrangements include the key milestones to complete the tasks. The determination
516 of task division and time arrangements relies on the learning outcomes of the
517 modeling and other BIM software. As PSD comments,

518

519 “When using Luban® software to produce construction schedules, you can
520 only make horizontal bar charts and output progress schedules, and cannot
521 convert them into a time-scale network. Therefore, if you need time-marked
522 network maps, you have to draw them manually. When you start the schedule,
523 it is necessary to take into account the time to create the hand-drawn,
524 time-scale, network map. You can use CAD® or Zebra Menglong® software
525 to draw the map. CAD® requires a lot of time and can provide nice drawings.
526 Menglong® is convenient to use, but the overall effect is not very
527 good-looking.”

528

529 Also, as PSF commented,

530

531 “Time considerations are critical in a capstone course. There is no time to
532 complete all the Project Planning modules. In the early stages of BIM
533 implementation, we should determine our own implementation plan.
534 Otherwise, it will affect the final results.”

535

536 (4) Strictly carrying out the formulated plan as far as possible. The team members carry
537 forward the project together and encourage each other. During the project, the team
538 needs full attendance and advances rapidly. If one or two individuals leave, it affects
539 the other team members. As PSE commented,

540

541 “In reinforcement modeling, we can use floor copying functions. It is
542 possible to divide the work into small tasks, finish individual parts first, and
543 finally merge them together. The premise is that the basic points of individual
544 parts are the same. Team members work together and they should discuss and
545 communicate with each other in a timely manner, which can relieve many
546 burdens and ensure the plan is well executed.”

547

548 PSB also commented that,

549

550 “The modeling process of the beam and slab reinforcement is affected by
551 mistakes in the drawings and unclear labels which, in turn, affects the
552 rationality and correctness of the model. Because of the tight schedule, our
553 team immediately discussed these issues and determined the solutions to
554 continue the work.”

555

556 (5) Learning modeling skills as early as possible. It takes to learn modeling through
557 videos during the internship time. The videos are simple and easy to follow.
558 However, a variety of small problems emerged in the actual operation. For example,
559 it always fails to recognize imported drawings in the BIM software. Such additional
560 issues might arise in the modeling processes as unrecognizable rebar symbols,
561 different rebar symbols in *CAD*®, and unmatchable fonts in text displays. These
562 issues need practical solutions that might not be fully automatic. As PSD
563 commented,

564

565 “We failed to import the PDS files exported from the steel reinforcement
566 models and civil models into Luban PE files or WORKS files. We were
567 unable to contact the person in charge of the customer support in the Luban
568 Software Company in time.”

569

570 According to PSF,

571

572 “The drawing lack information about the reinforcement at the junction of the
573 primary and secondary beams. The first layer contradicts the plate thickness

574 and plate reinforcement instructions. For example, *LBI* is 100, *C8@200*. But
575 in the following description, the layer thicknesses are 180 and the
576 reinforcement is double-layered.”

577

578 While PSG added that,

579

580 “Automatic checking cannot find some missing components. For example,
581 there are doors and windows in this area in the drawing. If there are
582 omissions, the doors or windows will be missing in the model that the
583 software cannot check. So the modeler must be careful and avoid missing
584 things. Problems must be checked and corrected carefully to avoid mistakes.”

585

586 Instructor Feedback

587 The course instructor also provided feedback on the observations of teaching and
588 learning experiences. In the case study, EL also made a positive contribution to the
589 development of the instructor. It enabled the instructor to connect the original
590 experiences with the characteristics of new situations. The experience provided new
591 meanings and promoted the instructor's cognitive development.

592 The course instructor suggested planning the teaching and learning process with
593 students early in the project planning and execution of a capstone course. Student
594 groups may wish to work with a professional BIM planning instructor or some
595 students/groups who had worked on the similar project in the past. Nevertheless, the
596 assignments in a capstone course do not usually relate to any current work that team
597 members may have with the project. For example, the course instructor considered the
598 implementation of BIM for multiple uses spanning across the planning, design,
599 construction, and/or operational phases of the project lifecycle. When integrating BIM
600 project planning into the course, the instructor should take into consideration that
601 students lack the systematic knowledge and skills of BIM project execution planning.
602 In the case study, the overall learning attitude of students was very positive, which was
603 an invaluable motivation for students to overcome many difficulties to learn new
604 knowledge and skills of BIM project planning. However, for most students in the class,
605 the course constituted a high-level strategy. The students needed time to familiarize

606 with the implementation of the strategy. There were time restrictions because of the
607 need to complete in 10 weeks. Due to the learning barriers caused by time, the students
608 had some worries and difficulties at the beginning of the course to progress the skills
609 and information exchanges needed. This condition did not cause negative learning
610 emotions and therefore did not hinder or inhibit student learning. The comprehensive
611 and detailed course method presented in this paper helped students to overcome the
612 obstacles.

613 In addition, the course instructor suggested paying attention to positioning the
614 instructor's role accurately in the project planning and execution of the course. The
615 instructors need four basic abilities in the process, comprising experience, reflection,
616 abstraction, and action (CE, RO, AC, AE) to make student-centered BIM project
617 planning learning possible. Furthermore, to promote the instructors' experience of
618 learning effectively, they need to learn from the establishment of the experiential
619 environment, differences in learning styles, instructor interactions with the
620 environment, and instructor introspection.

621 Moreover, instructors need to pay attention to the different learning styles of
622 students in team learning. Students are from different families, have different
623 personalities, and different levels of learning and cognitive abilities. Learning style and
624 learning effect closely relate to the iterative learning cycle. For example, in the
625 implementation the case study, the course instructor deliberated over the local
626 teaching-learning context. This affected the design of the student group size. Some
627 students may prefer to accept the guidelines from instructors in a passive way and don't
628 like to complete learning tasks through discussions and group work. This requires
629 instructors to observe how to balance classroom teaching, student homework, and
630 group presentations in the actual implementation processes.

631

632 **Conclusions, Limitations, Further Research**

633 The proposed framework applies experience learning to guide the implementation of a
634 BIM Project Planning course for CECM education. This framework includes EL into
635 the course curricula, which also highlights the formation of new knowledge combined
636 with transforming experiences in engineering education. Overall, the study provides a
637 theoretically grounded, empirically tested reference, and materials that can be adapted
638 to other similar engineering courses with the expansion of EL.

639 The study indicates that, for CECM education, site experiences contribute
640 significantly to the mastery of competencies in BIM education. The research further
641 shows that project planning plays an important role in realizing the successful
642 development of a BIM Project Planning course. In addition, it is possible that site
643 experience may speed up the learning of process mapping. Further, it effectively
644 strengthens the confidence to enrich the transition of students' experience into BIM
645 skills and management. To a large extent, it also prepares a readiness and highlights
646 the potential use the Kolb's EL in BIM project planning in teaching and learning tasks.
647 In short, this capstone course helps students improve their experience learning style to
648 develop communication procedures, technology, and quality control. It supports BIM
649 Project Planning course implementation.

650 There are three limitations to consider in this research. First, although the
651 research provides a sound reference, it has yet to be applied in other colleges and
652 universities. It has been carried out with a single case from Chang'an University in
653 China. Therefore, there is still much work to be done in future to test and develop the
654 framework with a large-scale application. Secondly, due to the capstone course
655 schedule and assigned students, the research includes only 10 BIM uses for project
656 planning. There are 15 remaining BIM uses need to incorporate into the proposed
657 pedagogy. In addition, the pedagogy should consider the student perceptions obtained,
658 along with the cognitive and learning outcomes using Kolb's EL. Instructors can
659 consider to integrate other education contents from related curricula into BIM Project
660 Planning capstone courses for CECM education. With experience learning, it is
661 possible to make the contents adapted for a variety of engineering and even
662 non-engineering disciplines. The third limitation is the lack of analysis of the learning
663 outcomes of BIM project planning between Kolb's EL with such other teaching
664 pedagogies as outcome-based learning and problem-based learning. Further research
665 is needed to compare the performance between the proposed framework and other
666 learning styles within cohort groups. In future research, it may be helpful to use a
667 qualitative model to analyze the reflections(i.e. NVIVO).

668

669 **Author Conflict:**

670 No potential conflict of interest is reported by the authors.

671

672 **Data Availability:**

673 The data generated or analyzed during the study are available from the first author
674 upon request at [TBA]

675

676 **Acknowledgment:**

677 This research is supported by the National Natural Science Foundation of China (No.
678 71301013); Humanity and Social Science Program Foundation of the Ministry of
679 Education of China (No. 17YJA790091); List of Key Science and Technology
680 Projects in China's Transportation Industry in 2018-International Science and
681 Technology Cooperation Project (2018-01639); Shaanxi Province Social Science
682 Fund (No. 2017S004, No. 2016ZB017, No. 2016Z047 and No. 2014HQ10); Shaanxi
683 Province Social Sciences Major Theoretical and Practical Research Fund
684 (No.2017Z028); Xi'an Social Science Fund (No. 18J139); Xi'an Science Technology
685 Bureau Fund (No.CXY1512(2)); Xi'an Construction Science and Technology
686 Planning Projects (No. SJW201705); Xi'an Science Technology Bureau Fund
687 (No.201805070RK1SF4(6)); Shaanxi Universities Second Batch of Youth
688 Outstanding Talents Support Projects((2018)111); Shaanxi Province Higher Education
689 Teaching Reform Project (17BZ017); Education Funding of Master of Engineering
690 Management in China(No. 2017-ZX-004); Shaanxi Province Civil Engineering
691 "first-class professional" project (No. 300103292801 and No. 300103292804);
692 Special Fund for Graduate Student Education Reform of Central College, Chang'an
693 University (No.300111002005, No. 300103187091, No. 310623176201,
694 No.310623176702, No.310628176702 and No.310628161406); Fundamental
695 Research for Education Reform of Central College, Chang'an University (No.
696 300104292304, No. 300104292305, No. 300104292308, No. 300103292806, No.
697 300104282301, No. 300104282318, No. 300104282323, No. 310623172904, No.
698 310623171003 and No. 310623171633); Fundamental Research for Funds for the
699 Central Universities (Humanities and Social Sciences), Chang'an University (No.
700 300102239616); Fundamental Research for Funds for the Central Universities,
701 Chang'an University (No. 300102238201).

702

703 **References:**

- 704 Ahn, Y. H., Cho, C.-S., and Lee, N. (2013). "Building Information Modeling:
705 Systematic Course Development for Undergraduate Construction Students."
706 Journal of Professional Issues in Engineering Education & Practice, 139(4), 290.
- 707 Andersson, N. A., and Högskolan i Halmstad, S. f. e. o. t. C. f. i. -e.-o. l. S. I. a. M. i. B.
708 O. (2013). "BIM Adoption in University Teaching Programs: The Swedish Case."
709 Proceedings of CITA BIM Gathering Conference 14-15 November 2013, 163.
- 710 Ayalp, G. G. (2015). "Relationships between Learning Approaches of Civil
711 Engineering Undergraduates in Three Turkish Universities and Success in
712 Construction Management Courses." International Journal of Engineering
713 Education, 31(6), 1504-1515.
- 714 Breunig, M. (2017). "Experientially Learning and Teaching in a Student-Directed
715 Classroom." Journal of Experiential Education, 40(3), 213-230.
- 716 Brown, A. O., Watson, K. A., Liu, J. C., Orabi, II, Rencis, J. J., Chen, C. C., Akasheh,
717 F., Wood, J. J., Jackson, K. S., Hackett, R. K., Sargent, E. R., Dunlap, B., Wejmar,
718 C. A., Crawford, R. H., Jensen, D. D., and Asee (2014). "Assessment of Finite
719 Element Active Learning Modules: An Update in Research Findings." 2014 Asee
720 Annual Conference, Amer Soc Engineering Education, Washington.
- 721 Cannon, B., Deb, S., Strawderman, L., and Heiselt, A. (2016). "Using
722 Service-Learning to Improve the Engagement of Industrial Engineering
723 Students." International Journal of Engineering Education, 32(4), 1732-1741.
- 724 Carrick, R., and Czekanski, A. (2017). "A Review of Outcome-Based Education and
725 the Use of Engineering Design Competitions to Improve Underrepresented
726 Attributes." International Journal of Engineering Education, 33(4), 1180-1188.
- 727 Casado, M. L., Lopez-Fernandez, D., and Lapuerta, V. (2016). "Socio-Emotional
728 Competencies in Engineering Education." International Journal of Engineering
729 Education, 32(4), 1660-1678.
- 730 Chegu Badrinath, A., Chang, Y. T., and Hsieh, S. H. (2016). "A review of tertiary BIM
731 education for advanced engineering communication with visualization."
732 Visualization in Engineering, 4(1), 9.
- 733 Clevenger, C. M., Ozbek, M. E., Fanning, B., and Vonfeldt, S. (2015). "Case Study of
734 Work-based Learning Involving BIM for Infrastructure in Support of Graduate

735 Construction Research." *International Journal of Construction Education &*
736 *Research*, 11(3), 163.

737 Demir, M., Gumusburun, E., Seringec, N., Cicek, M., Ertugrul, R., and Guneri, B.
738 (2018). "Radiographic analysis of the lumbar and sacral region angles in young
739 Turkish adults." *J. Pak. Med. Assoc.*, 68(8), 1212-1216.

740 Fridrich, J., and Kubecka, K. (2014). "BIM - The Process Of Modern Civil
741 Engineering In Higher Education." 4th World Conference on Learning Teaching
742 and Educational Leadership (Welta-2013), 141, 763-767.

743 Ganah, A. A., and John, G. A. (2017). "BIM and project planning integration for
744 on-site safety induction." *Journal of Engineering, Design and Technology*, 15(3),
745 341.

746 Ghosh, A., Parrish, K., and Chasey, A. D. (2015). "Implementing a Vertically
747 Integrated BIM Curriculum in an Undergraduate Construction Management
748 Program." *International Journal of Construction Education & Research*, 11(2),
749 121-135.

750 Giel, B., and Issa, R. R. A. (2016). "Framework for Evaluating the BIM Competencies
751 of Facility Owners." *J. Manage. Eng.*, 32(1), 15.

752 Gnaur, D., Svidt, K., and Thygesen, M. K. (2015). "Developing Students'
753 Collaborative Skills in Interdisciplinary Learning Environments." *International*
754 *Journal of Engineering Education*, 31(1), 257-266.

755 Helmi, S. A., Mohd-Yusof, K., and Phang, F. A. (2016). "Enhancement of Team-based
756 Problem Solving Skills in Engineering Students through Cooperative
757 Problem-based Learning." *INTERNATIONAL JOURNAL OF ENGINEERING*
758 *EDUCATION*, 32(6), 2401-2414.

759 Henderson, A., and Trede, F. (2017). "Strengthening attainment of student learning
760 outcomes during work-integrated learning: A collaborative governance
761 framework across academia, industry and students." *Asia-Pac. J. Coop. Educ.*,
762 18(1), 73-80.

763 Hongyuan, L., Lili, C., Lingfei, C., and Dexiang, H. (2010). Effects of Nitrogen and
764 Phosphorus Removal in Sequencing Batch Membrane Bioreactor with different
765 modes.

- 766 Ilozor, B. D., and Kelly, D. J. (2012). "Building Information Modeling and Integrated
767 Project Delivery in the Commercial Construction Industry: A Conceptual Study."
768 Journal of Engineering, Project & Production Management, 2(1), 23-36.
- 769 Jingxiao Zhang, H. X. a. H. L. (2017). "Competency-Based Knowledge Integration of
770 BIM Capstone in Construction Engineering and Management Education." The
771 International Journal of Engineering Education, 33(Number 6(B)), 2020-2032.
- 772 Jingxiao Zhang, W. W., Hui Li (2018). "Enhancing Building Information Modeling
773 Competency among Civil Engineering and Management Students with
774 Team-based Learning." ASCE, Journal of Professional Issues in Engineering
775 Education and Practice, 144(2), 05018001-05018001-05018001-05018013.
- 776 Le Cornu, R. (2016). "Professional experience: learning from the past to build the
777 future." Asia-Pac. J. Teach. Educ., 44(1), 80-101.
- 778 Malik, Q., Witte, J. C., Zafar, N., and Hussain, Z. (2017). "Influences on Freshman
779 Attitudes toward Engineering: Lessons from a Case Study of a Major Engineering
780 University in Pakistan." International Journal of Engineering Education, 33(2),
781 596-609.
- 782 Manolis, C., Burns, D. J., Assudani, R., and Chinta, R. (2013). "Assessing experiential
783 learning styles: A methodological reconstruction and validation of the Kolb
784 Learning Style Inventory." Learn. Individ. Differ., 23, 44-52.
- 785 Mathews, M. (2013). "BIM collaboration in student architectural technologist
786 learning." Journal of Engineering, Design & Technology, 11(2), 190.
- 787 Michelsen, S., Vabo, A., Kvilhaugsvik, H., and Kvam, E. (2017). "Higher Education
788 Learning Outcomes and their Ambiguous Relationship to Disciplines and
789 Professions." Eur. J. Educ., 52(1), 56-67.
- 790 Mora, C. E., Anorbe-Diaz, B., Gonzalez-Marrero, A. M., Martin-Gutierrez, J., and
791 Jones, B. D. (2017). "Motivational Factors to Consider when Introducing
792 Problem-Based Learning in Engineering Education Courses." International
793 Journal of Engineering Education, 33(3), 1000-1017.
- 794 Nabi, G., Linan, F., Fayolle, A., Krueger, N., and Walmsley, A. (2017). "The Impact of
795 Entrepreneurship Education in Higher Education: A Systematic Review and
796 Research Agenda." Acad. Manag. Learn. Educ., 16(2), 277-299.
- 797 Othman, H., Daud, K. A. M., Ewon, U., Salleh, B. M., Omar, N. H., Abd Baser, J.,
798 Ismail, M. E., Sulaiman, A., and Iop (2017). "Engineering Students: Enhancing

799 Employability Skills through PBL." Mechanical Engineering, Science and
800 Technology International Conference, Iop Publishing Ltd, Bristol.

801 Pikas, E., Sacks, R., and Hazzan, O. (2013). "Building Information Modeling
802 Education for Construction Engineering and Management. II: Procedures and
803 Implementation Case Study." Journal of Construction Engineering &
804 Management, 139(11), 1.

805 Rojas, E. M., and Dossick, C. S. (2008). "Developing a state-of-the-art facility to
806 support construction research and education: A case study." J. Prof. Issues Eng.
807 Educ. Pract., 134(1), 67-74.

808 Simelane-Mnisi, S., and Mji, A. (2015). "Establishing the Reliability and Validity of
809 the Kolb Learning Style Inventory: A South African Perspective." Int. J. Educ.
810 Sci., 11(3), 312-319.

811 Solnosky, R., Parfitt, M. K., and Holland, R. (2015). "Delivery methods for a
812 multi-disciplinary architectural engineering capstone design course." Archit. Eng.
813 Des. Manag., 11(4), 305-324.

814 Solnosky, R., Parfitt, M. K., and Holland, R. J. (2014). "IPD and BIM-Focused
815 Capstone Course Based on AEC Industry Needs and Involvement." J. Prof. Issues
816 Eng. Educ. Pract., 140(4), 11.

817 Stirling, A. a. s. u. c., Kerr, G., MacPherson, E., Banwell, J., Bandedy, A., and
818 Battaglia, A. (2017). "Do Postsecondary Internships Address the Four Learning
819 Modes of Experiential Learning Theory? An Exploration through Document
820 Analysis." Canadian Journal of Higher Education, 47(1), 27-48.

821 Thomas, K., Chisholm, G., Dempsey, B., Graham, B., and Stubbs, R. (2014).
822 "Collaborative BIM Learning via an Academia-Industry Partnership."
823 International Journal of 3-D Information Modeling, 3(1), 40.

824 Volk, R., Stengel, J., and Schultmann, F. (2014). "Building Information Modeling
825 (BIM) for existing buildings - literature review and future needs."
826 AUTOMATION IN CONSTRUCTION, 38, 109-127.

827 Wallin, P., Adawi, T., and Gold, J. (2017). "Linking teaching and research in an
828 undergraduate course and exploring student learning experiences." Eur. J. Eng.
829 Educ. (UK), 42(1), 58-74.

830 Watson, M. K., Pelkey, J., Noyes, C., and Rodgers, M. (2016). "Assessing impacts of
831 a learning-cycle-based module on students' conceptual sustainability knowledge
832 using concept maps and surveys." *Journal of Cleaner Production*, 133, 544-556.

833 Wu, W., and Hyatt, B. (2016). "Experiential and Project-based Learning in BIM for
834 Sustainable Living with Tiny Solar Houses." *Procedia Engineering*, 145, 579-586.

835 Zhang, D., and Gan, Y. (2005). "The Chinese Version of Utrecht Work Engagement
836 Scale: An Examination of Reliability and Validity." *Chinese Journal of Clinical
837 Psychology*, 13(3), 268-270,281.

838 Zhang, J., Schmidt, K., and Li, H. (2016). "BIM and Sustainability Education:
839 Incorporating Instructional Needs into Curriculum Planning in CEM Programs
840 Accredited by ACCE." *Sustainability* 8(6), 32.

841

842

843 **Figure captions**

844 Fig. 1. Proposed Framework of Designing Kolb's EL in a Capstone Course in CECM

845 Education

846 Fig. 2. Site Visit before the Start of the Course

847 Fig. 3. Process Mapping of Level 1 for AE in the course

848 Fig. 4. Site Utilization Planning Deliverables

849 Fig. 5. 3D Model Deliverables