Subject Description Form

Subject Code	BRE4661
Subject Title	Integrated Capstone Project
Credit Value	6
Level	4
Pre-requisite / Co-requisite / Exclusion	Pre-requisite: BRE366 (Analytical Skills and Methods) Exclusion: Any other equivalent capstone project, e.g. BRE466 (Capstone Project)
Objectives	The primary aim of the Integrated Capstone Project is to provide students with the opportunity of demonstrating research competence by providing them with a vehicle through which they can reveal a full understanding and evaluation of an issue or a topic that they choose to investigate. The Project is in the form of a final year Dissertation, and the issue or the topic should be based on the chosen programme major (i.e. Building Engineering and Management), together with the Artificial Intelligence and Data Analytics (AIDA) scheme as their Secondary Major, relevant to the construction industry with particular concerns to Hong Kong and its neighbouring environments. The specific objectives of this subject are to: • provide a student with the opportunity to apply and integrate the knowledge of artificial intelligence and data analytics (AIDA) to his/her chosen discipline of Building Engineering and Management; • develop the capabilities of a student in analyzing and solving complex and possibly real-life problems using AIDA knowledge and skills; and • Train students with skills on systematic development and documentation of a significant piece of work. The study might include an extensive literature review; the discovery, development or enhancement of a research model; the development of a measurement instrument, such as a questionnaire; or the comparison of statistical models for the evaluation of existing data. Where appropriate, students might join a departmental research group with AIDA expertise where they would be able to assist staff by working in a particular field of study.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: <u>Generally</u> a) display a culminating set of personal, academic and professional experiences/ learning; b) synthesize, integrate and/or apply previous knowledge instead of solely acquiring new knowledge/skills; c) apply general education principles; and d) engage in an interdisciplinary inquiry of at least two or more disciplines; <u>Specifically through academic / professional knowledge and skills</u>

	e) produce a research proposal related to a topic in the field of Building Engineering and Management with the identified problems to be solved using AIDA knowledge and skills; f) apply an appropriate research methodology to the chosen topic; g) conduct a critical and comprehensive literature review; h) identify specific problems, analyse data via AIDA knowledge and skills, evaluate findings and provide solutions via AIDA analytical results; i) communicate their ideas in a clear, concise and precise manner; and j) produce a study report that is based on their research and written in good English.
Subject Synopsis/ Indicative Syllabus	For those students choosing the Building Engineering and Management (BEM) programme as their Major and also opting for AIDA scheme as their Secondary Major, they are expected to identify a project topic in the field of Building Engineering and Management with the identified problems to be solved using AIDA knowledge and skills under the supervision of a supervisor with research expertise in artificial intelligence and data analytics. The topic should be engineering-oriented or engineering related area in construction. The Capstone Projects are grouped into a number of study areas within the research themes of the Department such as construction technology and science, production engineering, production and contract management, engineering economics, construction quality in engineering works, application of information or digital technology in the building industry, engineering materials, etc. Occasionally, if a student proposes a topic which is not within the context of engineering orientation, consideration and prior approval need to be sought from the BEM Programme Management Team. Students need to demonstrate their knowledge in both their chosen discipline (BEM) and AIDA in the project, receiving advice from the allocated supervisors. The project should represent requisite efforts in analysing and interpreting the data/information obtained, using the principles and techniques learned from various related subjects. Students are also expected to demonstrate significant analytical and, preferably, research ability in the chosen application domain of AIDA.
Teaching/Learning Methodology	Academic leadership is provided by the Departmental Capstone Project Committee comprising the BRE Undergraduate Scheme Chair and all the Programme Capstone Project Co-ordinators. The Committee is assisted by the supervisors who are BRE academic staff with research experience. The Integrated Capstone Project spans across the final year of study for two consecutive semesters (i.e. first semester and second semester). The teaching/learning activities include regular project meetings with the supervisors, guided study of project materials, independent project development work and other project management tasks. Each student will work under the guidance of a supervisor. The project supervision is timetabled for one hour per two weeks over the whole project study period, but students are expected to devote about a day per week of their own time to carry out study and research work. Students are encouraged to formulate a testable hypothesis with theoretical model or justifications; carry out an empirical test on the hypothesis; and draw inference(s) on research and practical implications from the findings.

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (please tick as appropriate)									
		a	b	c	d	e	f	g	h	i	j
1. Final Proposal	15 %	✓	✓			✓	✓	✓			
2. Progress and Effort Report	15 %		✓				✓	✓	✓		
3. Final Report	70 %			✓	✓		✓	✓	✓	✓	✓
Total	100 %										

Explanation of the appropriateness of the assessment methods in assessing the intended subject learning outcomes:

Integrated Capstone Project should be problem-oriented and there are no restrictions on the nature of the problem except that it should be relevant to the student's chosen discipline (BEM) and AIDA. The project could be practical, academic or a hybrid in which the student is encouraged but not constrained to have some original contributions. Each student has to submit a Final Proposal, a Progress and Effort Report and a Final Report. The Final Proposal must be approved by the supervisor before the student can proceed with the Integrated Capstone Project. A mid-term progress and effort report may also be required for proper continuous assessment.

The assessment of each of the three tasks (Final Proposal, Progress and Effort Report, and Final Report) will be made based on the established "Assessment Rubrics" that will be adopted and approved by the Capstone Project Committee. The "Assessment Rubrics" will be made available for reference by both students and supervisors on the Dissertation Guide mounted up to the blackboard subject website. The main assessment criteria are underlined below for reference.

Final Proposal

The Final Proposal should include a problem statement, a preliminary literature review, the study's research aim and objectives, an outline of the research methodology, means of data analysis, a reference list, and an outline schedule of work.

(1) Problem Statement: A concise and precise explanation of the problem that the research intends to address and an outline of the scope of study. This in effect provides the purpose of the study.

(2) Literature Review: A summary of the relevant theories, research evidence, and descriptive materials bearing on the proposed research, including all information, published or otherwise, that aids in understanding and helps to explain the background to the research.

(3) Research Aim and Objectives: Linking of the problem statement and literature review should be made through a precise statement of a research aim and a number of specific objectives. If a testable question (hypothesis) is to be used then this should be clearly stated. This section is a critical part of the research proposal because the aim and objectives need to be consistent with the purpose of the study.

(4) Research Methodology: A statement describing the research design and data collection techniques must be provided. The description must be sufficiently detailed to permit an understanding of the proposed study without discussion with the student. If a questionnaire survey is to be conducted, a provisional questionnaire should be included. Sources of data and sampling technique should be identified along with any restrictions on confidentially and possible problems in data collection. The time required for phases of the study should be specified.

(5) Data Analysis: The way in which the data will be analyzed, including any statistical analysis, should be outlined. If a non-standard form of data analysis is to be used, justification should be given. If computer programs are to be used, they should be identified.

(6) Reference and Bibliographic List: All works cited in the text of the Proposal must be listed under a section entitled References at the end of the Proposal immediately before the appendices. References are necessary in order to provide the reader with adequate information for locating cited materials. Students are recommended to use the **Harvard referencing system**, details of which can be found on websites such as: "https://elc.polyu.edu.hk/Referencing/harvard.aspx". Alternatively, students can refer to the Student Handbook for other referencing systems, provided that consistency is adhered to.

(7) Outline Schedule of Work: Students should include an outline programme in the form of a bar chart showing how they intend to perform the major activities and various tasks in order to meet the key milestone date requirements from inception to completion of their dissertation research, taking into account such intervening disruptions as examinations, study tours and public holidays.

Progress and Effort Report

During the progress of the research, the student and Supervisor will meet for consultation. It is the responsibility of students to arrange meetings with their supervisors in order that they may report and discuss their progress. It is expected that students devote sufficient time to the capstone project bearing in mind the requirements outlined in the subject description form.

Discussions with Supervisors are essential to explore the challenges faced by the student as they learn about the research topic through the whole research process. Thus, students are required to produce evidence of their work at their meetings with their Supervisors, so that the problems encountered can be shared and solved together.

Assessment Proforma for "Final Proposal and Progress Report" (weighted 30% towards the overall grade)

Assessment Components	Assessment Criteria	Weightings
Final Proposal	Adequacy, structure, clarity, originality, length	15%
Progress Report	Consultations, diligence, enthusiasm, planning of work, progress management	15%
Total		**30%**

Final Report

The Final Report should not normally exceed 10,000 words and is expected to include the following items: a declaration, an abstract, an introduction, research aim and objectives, literature review, research methodology, data collection, data analysis, and conclusions.

For the purpose of criterion-based assessment, the assessment of the completed Final Report is divided into six main elements, i.e. overall presentation, research aim and objectives, research methodology, literature review, data collection and analysis, conclusions and findings, with their corresponding weightings.

(1) Declaration: Each student shall print the statement identical to the one shown on Form BREDF4 (Completion Statement) on a fresh page, sign and incorporate in the submitted dissertation report as the first inside page.

(2) Abstract: A brief summary (200-400 words) of the research, normally including the main research objectives, the problems studied and the relevant theories, the methods of enquiry, and the most important results.

(3) Introduction: A description of the problems, along with detailed coverage of the theories and published research related to the research. This section often includes the reasons why the research merits study.

(4) Research Aim and Objectives: A re-statement of the research aim and objectives in the Final Dissertation Proposal (may be included in the Introduction).

(5) Literature Review: The literature search should be fully described showing the keywords and scientific databases used. A strong emphasis should be placed on refereed journal papers which can provide evidence of existing knowledge of the selected topic, obtained through scientific methods. The review should not only describe relevant theories, previous research, and descriptive material that have a bearing on the study, but also evaluate its worth. Evidence of independent analysis of the available literature should also be demonstrated. A basis for the chosen research topic should be established.

(6) Research Methodology: A clear statement of the planned research methods, as well as reporting of any ways in which the original methodology was modified as a result of constraints imposed in actually conducting the research. Some writers included this in the Introduction.

(7) Data Collection: This section should provide a clear and objective picture of the way in which the data was collected, including identification of any problems encountered and an explanation of the outcomes obtained. The data should be summarized and presented in an appropriate form, such as tables and diagrams, and not be evaluated or interpreted. Although some writers include analysis of the data in this section, others prefer to cover it separately.

(8) Data Analysis: This section should include the analysis and interpretation of the results of the research. The discussion should explain the degree to which the research objectives were achieved, the possible reasons for non-attainment of some research objectives, the ways in which the theories did or did not help to examine the problems, and an evaluation of the research results. In many reports, this section is the most important and often the longest in terms of words.

(9) Conclusions: The conclusions or outcomes of the study should be presented in this section. Included should be the major results that the study has achieved,

identification of unanswered questions and directions for further study, speculation about the importance of the findings to the body of knowledge in the construction and real estate fields and any other related items that the student wishes to emphasize.

(10) Reference and Bibliographic Lists: The Reference list should include full details of all publications cited in the Dissertation Report (see Item 4.6 for details), whereas the Bibliographic list (optional) contains details of all publications that have been used in the preparation.

(11) Appendices: The appendices should include copies of survey questionnaires, lengthy tables, graphs and lists not considered appropriate for inclusion within the main body of the Dissertation Report. Students should see the completed Dissertation Report as a holistic piece of scholarly work. The focus of the study topic should be clearly shown in the title, and throughout each chapter. The student should try to show the linkage between the various stages of the research process. Thus there should be 'signposting' throughout the written contents to explain how the chapters each contribute to the research objectives. For example, the literature review should link to the research objectives; the research objectives should link to the research methods; the research methods to the data analysis and explanation of the results; the results to the interpretation and discussion of implications; and finally to the conclusions.

Assessment Proforma for "Final Report" (weighted 70% towards the overall grade)

Assessment Items	Assessment Criteria	Weightings
Overall Presentation	Syntax, clarity, conciseness, preciseness, structure, aesthetics, graphics, length	10%
Research Aim and Objectives	Appropriateness and accomplishment of stated aim and objectives, accuracy of application	5%
Literature Review	Relevant parameters, adequate depth and breadth, accuracy, citations and references	15%
Research Methodology	Appropriateness, achievability, planning of research design, comprehensiveness, description	15%
Data Collection and Analysis	Relevancy, accuracy, adequacy, coherence of data analysis, logicality of interpretation	15%
Conclusions and Findings	Validity, logicality, substantiveness, originality, degree of critique, new ideas or models	10%
	Total	**70%**

Student Study Effort Required	Class contact:	
	▪ Guided study	10 Hrs.
	Other student study effort:	
	▪ Independent study	260 Hrs.
	Total student study effort	270 Hrs.

Reading List and References

Essential:

Department of Building and Real Estate of PolyU. *Dissertation Guide.* (continuously updated).

Recommended (General Research Methods and Skills):

Bell, J. (1993). *Doing Your Research Project*, Open University Press.

Blaikie, N. (2000). *Designing Social Research: The Logic of Anticipation*. Cambridge: Polity.

Booth, W.C., Colomb, G.G. and Williams, J.M. (2003). *The Craft of Research*, 2nd ed. Chicago: The University of Chicago Press.

Chau, K.W., Raftery, J. and Walker, A. (1998). The baby and the bathwater: Research methods in construction management. *Construction Management and Economics*, *16*(1), 99-104.

Fellows, R.F. and Liu, A.M.M. (2015). *Research Methods for Construction*, 4th edition, Blackwell Science.

Harris, R. and Cundell, I. (1995). Changing the property mindset by making research relevant. *Journal of Property Research*, *12*, 75-78.

Holt, G. (1998). *A Guide to Successful Dissertation Study for Students of the Built Environment*, 2nd edition. The Built Environment Research Unit, University of Wolverhampton, England.

Hussey, J. and Hussey, R. (2003). *Business Research: A Practical Guide for Undergraduate and Postgraduate Students*, 2nd edition, Basingstoke: Palgrave Macmillian, England.

Kennedy, P. (2003). *A Guide to Econometrics*, 5th edition, USA: Blackwell Publishing.

Knight, A. and Ruddock, L. (2008). *Advanced Research Methods in the Built Environment.* Chichester: Wiley-Blackwell.

Kumar, R. (1996). *Research Methodology: A Step-by-Step Guide for Beginners*. Addison Wesley Longman.

Levitt, R.E. (2007). CEM research for the next 50 years: Maximizing economic, environmental, and societal value of the built environment. *Journal of Construction Engineering and Management*, *133*(9), 619-28.

Levin, R.I. and Rubin, D.S. (1998). *Statistics for Management*, 7th edition, PrenticeHall.

Lizieri, C. (1995). Comment: Relevant research and quality research: The researcher's role in the property market. *Journal of Property Research, 12*, 163-166.

Lucey, T. (1992). *Quantitative Techniques, ELBS.*

Mason, J. (2002). *Qualitative Researching*. London: Sage.

Naoum, S.G. (1999). *Dissertation Research and Writing for Construction Students*, Butterworth-Heinemann.

Pindyck, R.S. and Rubinfeld, D.L. (1998). *Econometric Models and Economic Forecasts, 4th Edition*, Boston: McGraw-Hill International Editions.

Raftery, J., McGeorge, D. and Walters, M. (1997). Breaking up methodological monopolies: A multiparadigm approach to construction management research. *Construction Management and Economics, 15*(3), 291-297.

Render, B. and Stair, R.M. Jr (2000). *Quantitative Analysis for Management, 7th Edition*. Prentice Hall, New Jersey.

Tan, W. (2002). *Practical Research Methods*. Pearson Education Asia Pte Ltd., Singapore.

Recommended (Artificial Intelligence and Data Analytics / AIDA):

Bock, T. and Linner, T. (2016). Construction Robots Elementary Technologies and Single-Task Construction Robots. In *Construction Robots: Elementary Technologies and Single-Task Construction Robots* (p. I). Cambridge: Cambridge University Press.

Darko, A., Chan, A.P.C., Adabre, M.A., Edwards, D.J., Hosseini, M.R. and Ameyaw, E.E. (2020). Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities. *Automation in Construction, 112*, 103081.

Fan, H. and Li, H. (2013). Retrieving similar cases for alternative dispute resolution in construction accidents using text mining techniques. *Automation in Construction, 34*, 85-91.

Fan, H., Xue, F. and Li H. (2015). Project-based as-needed information retrieval from unstructured AEC documents. *Journal of Management in Engineering*, January, *31*(1).

Guo, B.H.W., Zou, Y., Fang, Y., Goh, Y.M. and Zou, P.X.W. (2021). Computer vision technologies for safety science and management in construction: A critical review and future research directions. *Safety Science, 135*, 105130. https://doi.org/10.1016/j.ssci.2020.105130

Hou, L., Wu, S., Zhang, G. (Kevin), Tan, Y. and Wang, X. (2020). Literature review of digital twins applications in construction workforce safety. *Applied Sciences*, *11*(1), 339. https://doi.org/10.3390/app11010339

Rafael Sacks, Chuck Eastman, Ghang Lee and Paul Teicholz (2018). *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*, 3rd Edition. Wiley.

Shen, L., Yan, H., Fan, H., Wu, Y. and Zhang, Y. (2017). An integrated system of text mining technique and case-based reasoning (TM-CBR) for supporting green building design. *Building and Environment*, *124*, 388-401.

Wang, D., Dai, F. and Ning, X. (2015). Risk assessment of work-related musculoskeletal disorders in construction: State-of-the-art review. *Journal of Construction Engineering and Management*, *141*(6), 04015008. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000979

Wang, Q. and Kim, M.K. (2019). Applications of 3D point cloud data in the construction industry: A fifteen-year review from 2004 to 2018. *Advanced Engineering Informatics*, *39*, 306-319. https://doi.org/10.1016/j.aei.2019.02.007

Yan, H., Yang, N., Peng, Y. and Ren, Y. (2020). Data mining in the construction industry: Present status, opportunities, and future trends. *Automation in Construction*, *119*, 103331.

Zacharias, Voulgaris and Yunus, Emrah Bulut (2018). AI for Data Science: Artificial Intelligence Frameworks and Functionality for Deep Learning, Optimization, and Beyond. First Edition, Technics Publications.

Machine Learning: https://www.coursera.org/learn/machine-learning/home/welcome

MathWorks: https://www.mathworks.com/solutions.html?s_tid=gn_sol