25th International Conference on Computers in Education

"Technology and Innovation: Computer-based Educational Systems for the 21st Century"

Main Conference Proceedings

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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Paper Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C1: Artificial Intelligence in Education/Intelligent Tutoring System (AIED/ITS) and Adaptive Learning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigating the effects of Cognitive and Metacognitive Scaffolding on Learners using a Learning by Teaching Environment</td>
<td>Cristina Dumdamaya, Michelle Banawan, Ma. Mercedes T. Rodrigo, Amy Ogan, Evelyn Yarzebinski and Noburo Matsuda</td>
<td>1</td>
</tr>
<tr>
<td>Learning arithmetic word problem structure with a picture combination application in Kindergarten</td>
<td>Pedro Gabriel Fonteles Furtado, Tsukasa Hirashima, Yusuke Hayashi and Kazumasa Maeda</td>
<td>11</td>
</tr>
<tr>
<td>Framework for Building a Thinking Processes Analysis Support System: A Case Study of Belief Conflict Thinking Processes</td>
<td>Yuki Hayashi, Kazuhisa Seta and Mitsuru Ikeda</td>
<td>21</td>
</tr>
<tr>
<td>Usability and Learning Effect Evaluations of an Electrical Note-Taking Support System with Speech Processing Technologies</td>
<td>Hiromitsu Nishizaki and Yosuke Narita</td>
<td>31</td>
</tr>
<tr>
<td>A Student Placement Predictor for Programming Class Using Class Attitude, Psychological Scale, and Code Metrics.</td>
<td>Ryosuke Ishizue, Kazunori Sakamoto, Hironori Washizaki and Yoshiaki Fukazawa</td>
<td>40</td>
</tr>
<tr>
<td><strong>Short papers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding Support System for Causal Relationship in Historical Learning</td>
<td>Tomoko Kojiri, Fumito Nate and Keitaro Tokutake</td>
<td>50</td>
</tr>
<tr>
<td>Extraction of Relationships between Learners’ Physiological Information and Learners’ Mental States by Machine Learning</td>
<td>Yoshimasa Tawatsuji, Tatsuro Uno, Keita Okazaki, Siyuan Fang and Tatsunori Matsui</td>
<td>56</td>
</tr>
<tr>
<td>Predicting Student Carefulness within an Educational Game for Physics using Support Vector Machines</td>
<td>Michelle Banawan, Ma. Mercedes Rodrigo and Juan Miguel L. Andres</td>
<td>62</td>
</tr>
<tr>
<td>GPT: A Tutor for Geometry Proving</td>
<td>Roscoe Nealle Alichusan, Laurence Nicholas Foz, Paolo Vittorio Merle, Ethel Chua Joy Ong and Minie Rose Lapinid</td>
<td>68</td>
</tr>
<tr>
<td>Inquiry-based Support System to Improve Intention Sharing Skills</td>
<td>Natsumi Mori, Yuki Hayashi and Kazuhisa Seta</td>
<td>74</td>
</tr>
<tr>
<td>A Tool for data acquisition of thinking processes through writing</td>
<td>Wasan Na Chai, Taneth Ruangrajitpakorn and Thepchai Supnithi</td>
<td>80</td>
</tr>
<tr>
<td>An Artificial Intelligence Approach to Identifying Skill Relationship</td>
<td>Tak-Lam Wong, Yuen Tak Yu, Chung Keung Poon, Haoran Xie, Fu Lee Wang and Chung Man Tang</td>
<td>86</td>
</tr>
</tbody>
</table>
### Posters

- **Development of a System to Construct Explanation for Physics Phenomenon through Thought Experiment**
  - Miki Matsumuro, Kazuhisa Miwa and Yuiko Tombe

- **Towards a Virtual Peer to Write Stories with Children**
  - Hans Gabriel Chua, Geraldine Elaine Cu, Chester Paul Ibarrientos, Moira Denise Paguligan and Ethel Ong

- **Prospects in Modeling Reader's Affect based on EEG Signals**
  - Kristine Kalaw, Ethel Ong and Judith Azcarraga

- **Proposal of an Intelligent Tutoring System for procedural learning with Context-aware Dialogue**
  - Jose Paladines and Jaime Ramirez

- **Improvement of the Situational Dialog Function and Development of Learning Materials for a Japanese Dictogloss Environment**
  - Satoru Kogure, Kaito Okugawa, Yasuhiro Noguchi, Tatsuhiro Konishi, Makoto Kondo and Yukihiro Itoh

- **Semantically Enhanced Gaze-aware Historical Cartoons to Encourage Historical Interpretation**
  - Daiki Muroya, Yuki Hayashi and Kazuhisa Seta

- **Developing a Geometric Proof Problem-Solving Support System Utilizing Card Selection**
  - Megumi Kurayama

- **Analyzing Novice Programmers’ EEG Signals using Unsupervised Algorithms**
  - Vanlalhrualii Swansi, Tita Herradura and Merlin Suarez

- **Evaluation of mathematics knowledge level through personalized learning exercise based on the Adaptive Tests**
  - Yan Liu, Chuxin Fu and Xiaoqing Gu

### C2: Computer-supported Collaborative Learning (CSCL) and Learning Sciences

#### Full Papers

- **Discovering Dynamics of an Idea Pipeline: Understanding Idea Development within a Knowledge Building Discourse**
  - Alwyn Vwen Yen Lee and Seng Chee Tan

- **Using CSCL to Conceptualize Disability Toward Inclusive Education Design**
  - Christopher P. Ostrowski

- **Measuring Process and Outcome of the Scientific Argumentation in a CSCL Environment**
  - Wenli Chen and Chee Kit Looi

- **Case-based Portraits of Contrasting Micro-Interaction Processes During Online Assessment of Collaborative Problem Solving**
  - Johanna Pöysä-Tarhonen, Esther Care, Nafisa Awwal and Päivi Häkkinen

- **DBCollab: Automated Feedback for Face-to-Face Group Database Design**
  - Vanessa Echeverria, Roberto Martinez-Maldonado, Katherine Chiluiza and Simon Buckingham Shum

- **Examining Student Learning of Engineering Estimation from METTLE**
  - Aditi Kothiyal and Sahana Murthy

- **Social Media Facilitated Group Performance: An Investigation of Tie Strength in Grouping**
  - Cong Qi

#### Short papers

- **Impact of Both Prior Knowledge and Acquaintanceship on Collaboration and Performance: A Pair Program Tracing and Debugging Eye-Tracking Experiment**
  - Maureen Villamor and Ma. Mercedes Rodrigo
A Toolkit for Action: Translating Theory into Practice

Exploratory Analysis of Discourses between Students Engaged in a Debugging Task

Analyzing a Practical Implementation of Training Metacognition through Solving Mathematical Word Problems

Designing the EMBeRS Summer School: Connecting Stakeholders in Learning, Teaching and Research

Why Learners Fail in MOOCs? Investigating the Interplay of Online Academic Hardiness and Learning Engagement among MOOCs Learners

Toddlers Testing DDMM: Evaluation Results and Ideas towards Creating Better Learning Environments for Small Children

Effects of Peer Interaction on Web-Based Computer Programming Learning

Lucila Carvalho and Pippa Yeoman

Ma. Mercedes T. Rodrigo

Tama Duangnamol, Thepchai Supnithi, Gun Srijuntongsri and Mitsuru Ikeda

Kate Thompson, Antje Danielson, David Gosselin, Simon Knight, Roberto Martinez-Maldonado, Roderic Parnell, Deana Pennington, Julia Svoboda-Gouvea, Shirley Vincent and Penny Wheeler

Tonny Meng-Lun Kuo, Chin-Chung Tsai and Jyun-Cheng Wang

Christine Steinmeier and Dominic Becking

Nuttaphat Arunoprayoch, Chih-Hung Lai, Pham-Duc Tho and Jing-San Liang

Posters

Exploring Lag Times in a Pair Tracing and Debugging Eye-Tracking Experiment

The Research of Interaction Performance of Intercultural Communication in Computer-supported Collaborative Learning

Collaborative Learning in Elementary Science Supported by Learning by Inquiry and Augmented Reality

Collaborative Inductive Problem Solving Using an ICT Tool in an Elementary Science Classroom

The Design of a Portfolio-Based Reading Conversation Platform

Improving Reading Comprehension using the Cooperative Mind Mapping Summary Strategy

Maureen Villamor and Ma. Mercedes Rodrigo

Yi Wei, Li-Jie Wu and Yi-Ling Hu

Sie Wai Chew, I-Hsiu Lin, Kinshuk and Nian-Shing Chen

Hirokazu Kawano and Shu Matsuura

Tzu-Chao Chien, Zhi-Hong Chen and Tak-Wai Chan

Gloria Yi-Ming Kao, Ju-I Cheng and Chin-Chung Tsai

C3: Advanced Learning Technologies (ALT), Learning Analytics and Digital Infrastructure

Full Papers

Resource Description Framework (RDF) Models for Representing the Revision Process in Research Support Systems

Extracting Implicit Suggestions from Students’ Comments – A Text Analytics Approach

Semi-Discovery Learning Support System for Analogical Reasoning in High-School Physics

Harriet Ocharo and Shinobu Hasegawa

Venky Shankararaman, Swapna Gottipati and Jeff Lin Rongsheng

Yasuhiro Noguchi, Takeshi Enokida, Tatsuhiro Konishi and Yukihiro Itoh
Using Data Analytics for Discovering Library Resource Insights – Case from Singapore Management University
Lu Ning, Song Rui, Dina Heng Lie Gwek, Swapna Gottipati and Aaron TAY

An Educational Support System based on Automatic Impasse Detection in Programming Exercises
Koichi Yamashita, Takumi Sugiyama, Satoru Kogure, Yasuhiro Noguchi, Tatsuhiro Konishi and Yukihiro Itoh

A Bibliometric Analysis of 15 Years of Research on Open Educational Resources
Xiaochen Wang, Mengrong Liu, Qianhui Li and Yuan Gao

Design and Implementation of a Pedagogic Intervention Using Writing Analytics
Antonette Shibani, Simon Knight, Simon Buckingham Shum and Philippa Ryan

Multimodal Interaction Aware Platform for Collaborative Learning
Aoi Sugimoto, Yuki Hayashi and Kazuhisa Seta

Using Network-Text Analysis to Characterise Learner Engagement in Active Video Watching
Tobias Hecking, Vania Dimitrova, Antonija Mitrovic and H. Ulrich Hoppe

Synergizing Online Group Knowledge
Yen-An Shih and Ben Chang

A Presentation Avatar for Self-Review
Keisuke Inazawa and Akihiro Kashihara

Cognitive Investigation of Dynamic Educational Presentation toward Better Utilization of Presentation Characteristics
Yasuhisa Okazaki and Atsushi Yoshikawa

The Journey to Improve Teaching Computer Graphics: A Systematic Review
Thomas Suselo, Burkhard Wuesche and Andrew Luxton-Reilly

Designing a "Three Rings" Theory Framework for Electronic Schoolbag
Baoyuan Yin, Fati Wu, Shihua Huang and Shan Jia

Interaction between Standardisation and Research in Drafting an International Specification on Learning Analytics
Tore Hoel and Wei Qin Chen

An Evaluation of Elementary Students’ Ability of Problem Solving in Information Processing
Lishan Zhang, Jing Wang, Zijun Zhuang and Baoping Li

Algorithm Learning by Comparing Visualized Behavior of Programs
Daiki Ihara, Satoru Kogure, Yasuhiro Noguchi, Koichi Yamashita, Tatsuhiro Konishi and Yukihiro Itoh

Analyzing the E-learning Video Environment Requirements of Generation Z Students using Echo360 Platform
Swapna Gottipati and Venky Shankararaman

Train-For-Life: On-Line Interactive Training for Industry Learners
Bashar Barmada and Nilufar Baghaei

Detect Students’ Academic Emotions in Classroom: Measurement, Self-perception and Manifested Behaviors
Yan Liu, Menghua Hu and Xiaoqing Gu

Authoring Tool: a Collaborative Web Tool for eBooks Creation
Dilson Rabelo, Ana Emilia Oliveira, Carla Spinillo, Aldrea Rabelo and Rômulo Françaand

Observing the Degree of Distortion in Coordinated Motor Actions
Takehiko Yoshikawa, Kohta Sugawara, Kenji Matsuura, Stephen Karungaru and Naka Gotoda
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Environment for Recursive Functions by Visualization of Execution Process</td>
<td>Raiya Yamamoto, Yasuhiro Anzai, Satoru Kogure, Yasuhiro Noguchi, Koichi Yamashita, Tatsuhiko Konishi and Yukihiro Itoh</td>
<td>421</td>
</tr>
<tr>
<td>Can Distributed Practice Improve Students’ Efficacy in Learning their First Programming Language?</td>
<td>Qiujie Zhang, Lishan Zhang, Baoping Li, Ling Chen, I-Han Hsiao and Fati Wu</td>
<td>427</td>
</tr>
<tr>
<td>Cross Analytics of Student and Course Activities from e-Book Operation Logs</td>
<td>Atsushi Shimada and Shinichi Konomi</td>
<td>433</td>
</tr>
<tr>
<td>Students’ Performance Prediction Using Data of Multiple Courses by Recurrent Neural Network</td>
<td>Fumiya Okubo, Takayoshi Yamashita, Atsushi Shimada and Shinichi Konomi</td>
<td>439</td>
</tr>
<tr>
<td>A Case Study of Interactive Learning Environment for Building Structure of Arithmetic Word Problem in Language Delay</td>
<td>Sho Yamamoto and Tsukasa Hirashima</td>
<td>445</td>
</tr>
<tr>
<td>A Learning Support System for Integrated Motor Skill by Organized Training Stages</td>
<td>Kohta Sugawara, Takehiko Yoshikawa, Kenji Matsuura, Stephen Karungaru and Naka Gotoda</td>
<td>451</td>
</tr>
<tr>
<td>Enhancing Students’ Critical Reading Fluency, Engagement and Self-Efficacy using Self-Referenced Learning Analytics Dashboard Visualizations</td>
<td>Christin Jonathan, Jennifer Pei-Ling Tan, Elizabeth Koh, Imelda Caleon and Siu Hua Tay</td>
<td>457</td>
</tr>
<tr>
<td>Coloring Strategy Combined with Three-Dimensional Animation: Does the Mental Strategy Fits Everyone?</td>
<td>Jiayu Chu, Yiling Hu, Shiyu Wang and Xiaqing Gu</td>
<td>463</td>
</tr>
<tr>
<td>Development of Alternative Conception Diagnostic System based on Item Response Theory in MOOCs</td>
<td>Yu-Cheng Cheng, Jian-Wei Tzeng, Nen-Fu Huang, Chia-An Lee and Meng-Lun Kuo</td>
<td>469</td>
</tr>
<tr>
<td>Capturing Changes and Variations from Teachers’ Time Series Usage Data</td>
<td>Longwei Zheng, Rui Shi and Xiaqing Gu</td>
<td>475</td>
</tr>
<tr>
<td>TGlass: A Custom-made Wearable Promoting Accessibility for Tetraplegic</td>
<td>Maikon Soares, Felipe Bede, Thiago Araujo, Daniel Cavalcante, Adriano Freitas, Zulma Carvalho and Francisco Oliveira</td>
<td>481</td>
</tr>
</tbody>
</table>

**Posters**

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Reality based Learning Support System for Mental Rotation</td>
<td>Midori Nakano, Yukihiro Matsubara, Masaru Okamoto and Noriyuki Iwane</td>
<td>487</td>
</tr>
<tr>
<td>Monitoring System to Help an e-Learning Institution to Manage Tutors and Student Data Retrieved from Moodle</td>
<td>Elza Monier, Fátima Gatinho, Ana Emilia Oliveira, Aldrea Rabelo and Rômulo Martins</td>
<td>490</td>
</tr>
<tr>
<td>A Study on Prediction of Academic Performance based on Current Learning Records of a Language Class using Blended Learning</td>
<td>Byron Sanchez, Xiumin Zhao, Takashi Mitsuishi and Terumasa Aoki</td>
<td>493</td>
</tr>
<tr>
<td>The Development of a Simulation to Support Authentic Observation in Precipitation Reaction</td>
<td>Chang Youn Lee and Hun-Gi Hong</td>
<td>496</td>
</tr>
<tr>
<td>Kanji Learning Support with Feedback based on Haptic and Pseudo-Haptic</td>
<td>Takanori Kono, Yukihiro Matsubara and Masaru Okamoto</td>
<td>499</td>
</tr>
<tr>
<td>Discourse Analysis of Teachers’ Commentary on Students</td>
<td>Rui Shi, Longwei Zheng and Xiaqing Gu</td>
<td>502</td>
</tr>
</tbody>
</table>
Discovering Teachers’ In-Class ICT Usage With Frequent Closed Sequence Mining

Support for the Cycle of Task Extraction, Goal Setting and Assessment in Research Activities

AR-based Inorganic Chemistry Learning Support System using Mobile HMD

Analysis on Students’ Usage of Highlighters on E-textbooks in Classroom

Taxonomy for Teacher-Actionable Insights in Learning Analytics

---

**C4: Classroom, Ubiquitous, and Mobile Technologies Enhanced Learning (CUMTEL)**

<table>
<thead>
<tr>
<th>Full Papers</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Architecture and Predictive Experiment for an Automatic Learning Support Function on Classroom Response Systems</td>
<td>Kozo Mizutani</td>
<td>520</td>
</tr>
<tr>
<td>Enhancing Seamless Learning Using Learning Log System</td>
<td>Noriko Uosaki, Hiroaki Ogata and Kousuke Mouri</td>
<td>529</td>
</tr>
<tr>
<td>Students’ Participative Stances and Knowledge Construction in Small Group Collaborative Learning with Mobile Instant Messaging Facilitation</td>
<td>Ying Tang, Khe Foon Hew and Gaowei Chen</td>
<td>539</td>
</tr>
<tr>
<td>Learning Behavioral Pattern Analysis based on Students’ Logs in Reading Digital Books</td>
<td>Chengjiu Yin, Noriko Uosaki, Hui-Chun Chu, Gwo-Jen Hwang, Jau-Jian Hwang, Itsuo Hatono, Etsuko Kumamoto and Yoshiyuki Tabata</td>
<td>549</td>
</tr>
<tr>
<td>A Case study of Evaluation of Learners’ Acceptance of AR_H2O2 System</td>
<td>Tao Wang, Shan Jia, Jirui Dai, Manli Lu, Su Cai and Feng-Kuang Chiang</td>
<td>558</td>
</tr>
<tr>
<td>An Empirical Case on Integration of Immersive Virtual Environment into Primary School Science Class</td>
<td>Jian Sun, Hao Li, Zhanhao Liu, Su Cai and Xiaowen Li</td>
<td>566</td>
</tr>
<tr>
<td>Online Synchronous Discussion in Face-to-Face Classroom Based on WeChat</td>
<td>Manli Lu, Guang Chen and Shuxian Ouyang</td>
<td>576</td>
</tr>
<tr>
<td>Teachers’ Concerns about Adopting Interactive Spherical Video-based Virtual Reality</td>
<td>Jie Geng, Tsun Hin Eric Luk and Siu Yang Morris Jong</td>
<td>586</td>
</tr>
<tr>
<td>How Designer Think About Designing an Augmented Reality App for the Study of Central Nervous System</td>
<td>Fadzil Saleh Mohamad Rofie and Mas Nida Md. Khambari</td>
<td>594</td>
</tr>
<tr>
<td>A Comparison of Different Types of Learning Activities in a Mobile Python Tutor</td>
<td>Geela Venise Firmalo Fabric, Antonija Mitrovic and Kourosh Neshatian</td>
<td>604</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Short papers</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Case study of Young Children’s Use of iPad for Digital Storytelling for a Study of Self</td>
<td>Leigh Disney and Gretchen Geng</td>
<td>614</td>
</tr>
<tr>
<td>Online Responses towards the Impact of Hand Held Devices on Children’s Social and Emotional Development</td>
<td>Gretchen Geng and Leigh Disney</td>
<td>620</td>
</tr>
</tbody>
</table>
Applying Pedagogy to the Design of Software for Helping Students Learn Equation Solving

Daphne Robson

The Development of Mobile Learning CPD Modules to Improve the Management of Respiratory Diseases

Georgina Orsborn, Teresa Demetriou, Kerri Arcus and Elizabeth Ashbury

The Effectiveness of Media Platforms on Reading Comprehension: A Meta-analysis

Bing Xu, Guang Chen, Yuting Sun and Ronghuai Huang

Explore the Impact of Collaborative Tendencies in the Flipped Classroom on Taking Basketball Teaching

Tosti H. C. Chiung

Teaching Influence for Perceived Usefulness of Interactive Whiteboard - Based on the Perspective of College Students

Peng Zhou, Zhexu Liu and Jian Xu

Designing Boundary Activity for Mobile Learning in Science Inquiry

Daner Sun and Chee-Kit Looi

Responsive eBook based on the Principles of Educational Interfaces

Ana Emilia Oliveira, Elza Monier, Dilson Rabelo, Fátima Gatinho, Aldrea Rabelo and Marcelo Henrique Montier Alves Junior

Encouraging System for Teaching Assistants to Advise Students during Programming Exercises

Yuuki Yokoyama and Hironori Egi

Improving Primary Students’ Problem Solving Skills in Science Learning in a Seamless Learning Environment

Yanjie Song and Ka Man Lung

Blockino: a Tool with an Emphasis on Educational Robotics Assisting the Teaching of Programming Logic

Higo Sampaio, Mauro Silva, Aldrea Rabelo, Carla Marques and Marcelo Monier

Effects of Prior Knowledge of High Achievers on Use of e-Book Highlights and Annotations

Misato Oi, Fumiya Okubo, Yuta Taniguchi, Masanori Yamada and Shinichi Konomi

Promoting Extrinsic Motivation Based on Result of LMS Quiz

Yasutaka Asai and Hironori Egi

An Electronic ID System Using a Smart Phone

Jaewook Kim, Takashi Tachino and Yasuhito Kishi

Social Network Analysis of Teacher’s Role in Students’ Online Discussion Community

Chih-Ming Chu

Exploring the Nature of Teacher’s Ongoing Feedback to Pupil using iPad

Weiyun Chen, Yaofeng Xue and Xiaoqing Gu

Development of a Community-based Hazard Information Sharing System for Traditional Towns with Local Heritage

Shun Kozaki, Yasuhisa Okazaki, Hiroshi Wakaya, Yukuo Hayashida, Byung-Won Min and Nobuo Mishima

Educational Effectiveness of a System for Scientific Observation of Animals in a Zoo

Yui Tanaka, Ryuhei Egnu, Yuuki Dobashi, Fusako Kusunoki, Etsuji Yamaguchi, Shigenori Inagaki and Tomoyuki Nogami

Leveraging an Existing Learning Management System for Alternative Learning

Mikaela Malit and Ma. Mercedes Rodrigo

Posters
### Full Papers

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing Regular Assessments and Earlier Feedback on Moodle in an Introductory Computer Science Course: A User Study</td>
<td>Natalia Nehring, Simon Dacey and Nilufar Baghaei</td>
<td>721</td>
</tr>
<tr>
<td>Study on Implementing Automated Classroom Performance System for Recording Student Attendance</td>
<td>Daniel Mangalaraj and Shankar Subramanian</td>
<td>724</td>
</tr>
<tr>
<td>Stream-based Reasoning for IoT Applications on Domain Education</td>
<td>Marcelo Alves Júnior, Francisco Silva, Markus Endler, Vitó Almeida and Higo Sampaio</td>
<td>727</td>
</tr>
<tr>
<td>A Meta Analysis: The Effectiveness of E-Schoolbag Use on Students’ Academic Achievement in China</td>
<td>Menghua Hu and Yiling Hu</td>
<td>730</td>
</tr>
<tr>
<td>Real-time Analysis of Digital Textbooks: What Keywords Make Lecture Difficult?</td>
<td>Koussuke Mouri, Atsushi Shimada, Chengjiu Yin, Usaki Noriko, Yachirawit Tengchaisri and Keichki Kaneko</td>
<td>733</td>
</tr>
</tbody>
</table>

### Short Papers

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Currency as Gamification for Learning in a Disaster Museum to Increase the Number of Revisitors</td>
<td>Hiroyuki Mitsuhara and Masami Shishibori</td>
<td>746</td>
</tr>
<tr>
<td>“Go Kahoot!” Enriching Classroom Engagement, Motivation and Learning Experience with Games</td>
<td>Sherlock Licorish, Jade Li George, Helen Owen and Ben Daniel</td>
<td>755</td>
</tr>
<tr>
<td>JobStar Online: Game-Based Learning on Smartphones to Promote Youth Career Education</td>
<td>Toru Fujimoto, Yuki Fukuyama, Satoko Azami and Satoru Konno</td>
<td>765</td>
</tr>
<tr>
<td>Sufficiency Economy Philosophy-Based Mobile Game Application to Promoting Sustainability Understanding based on Inquiry Learning with Everyday Life Activities</td>
<td>Charoenchai Wongwatkit, Muttakeen Che-Leah, Sasithorn Chookaew, Jintana Wongta, Chitphon Yachulawetkunakorn and Ratthakarn Na Phatthalung</td>
<td>774</td>
</tr>
<tr>
<td>The Digital Interactive Learning Theater in the Classroom for Drama-based Learning</td>
<td>Yu-Tzu Liu, Shang-Chiao Lin, Wei-Yi Wu and Gwo-Dong Chen</td>
<td>784</td>
</tr>
<tr>
<td>Learning Support System for Museum exhibits using Complex Body Movements --Enhancing Sense of Immersion in Paleontological Environment</td>
<td>Mikihiro Tokuoka, Hiroshi Mizoguchi, Ryohei Egusa, Shigenori Inagaki, Fusako Kusunoki and Masanori Sugimoto</td>
<td>790</td>
</tr>
<tr>
<td>SATOYAMA: Simulating and Teaching Game Optimal for Young Children to Learn Vegetation Succession as Management of an Actual Forest</td>
<td>Shuya Kawaguchi, Hiroshi Mizoguchi, Ryohei Egusa, Yoshiaki Takeda, Etsuji Yamaguchi, Shigenori Inagaki, Fusako Kusunoki, Hideo Funaoi and Masanori Sugimoto</td>
<td>796</td>
</tr>
<tr>
<td>Muse: A Musically Inspired Game To Teach Arrays and Linked Lists</td>
<td>Vaishali Sharma, Raghib Musarrat, Sridhar Chimalakonda and Y Raghu Reddy</td>
<td>802</td>
</tr>
<tr>
<td>Healthy Kidney: An Educational Game for Health Awareness</td>
<td>Sandra Hammedi, Fathi Essalmi and Maiga Chang</td>
<td>808</td>
</tr>
</tbody>
</table>
### Posters

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Effects of SDE Strategy-based Computer Games on Metacognitive Awareness</td>
<td>Kai-Hsiang Yang, Chin-Yen Lu and Bou-Chan Lu</td>
<td>814</td>
</tr>
<tr>
<td>Scaffolding historical inquiry through a collaborative maker-based activity</td>
<td>Benjamin Lille and Margarida Romero</td>
<td>817</td>
</tr>
<tr>
<td>A Study of Design Thinking Adaptation for Maker Education Process</td>
<td>Peng Chen, Ding Li and Ronghui Huang</td>
<td>820</td>
</tr>
<tr>
<td>A POE Strategy-Based Gaming Approach for Mathematics Learning</td>
<td>Kai-Hsiang Yang, Hsiao-Hua Chen and Bou-Chuan Lu</td>
<td>823</td>
</tr>
<tr>
<td>Probing in-service Teachers’ Perceptions on TPACK-G and Acceptance of GBL</td>
<td>Chung-Yuan Hsu, Jyh-Chong Liang, Ching Sing Chai and Chin-Chung Tsai</td>
<td>826</td>
</tr>
<tr>
<td>Game-based Narrative System for Student English Learning</td>
<td>Zhi-Hong Chen</td>
<td>829</td>
</tr>
<tr>
<td>Exploring Teachers’ Pedagogical Design Thinking in Game-based Learning</td>
<td>Mingfong Jan, Wan-Lin Yang and Michael Thomas</td>
<td>832</td>
</tr>
</tbody>
</table>

### Full Papers

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can Conversational Agents Foster Learners’ Willingness To Communicate in a Second Language? : Effects of Communication Strategies and Affective Backchannels</td>
<td>Emmanuel Ayedoun, Yuki Hayashi and Kazuhisa Seta</td>
<td>835</td>
</tr>
<tr>
<td>Multimodality in Language Education – Exploring the Boundaries of Digital Texts</td>
<td>Anna-Lena Godhe and Petra Magnusson</td>
<td>845</td>
</tr>
<tr>
<td>Effectiveness of a Learning Design Combining Summary-speaking Self-study Using Mobile Application with Paired Reflection on Learners’ Speaking Process</td>
<td>Kae Nakaya and Masao Murota</td>
<td>855</td>
</tr>
<tr>
<td>Discussion Course Model Using Online Educational Resources to Enhance EFL Learners’ Motivation and Critical Thinking</td>
<td>Yuichi Ono and Ai Nakajima</td>
<td>865</td>
</tr>
<tr>
<td>Reading for Emotion with ICT Tools</td>
<td>Ania Lian</td>
<td>874</td>
</tr>
</tbody>
</table>

### Short papers

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Classification of Teacher Feedback and Its Potential Applications for EFL Writing</td>
<td>Gary Cheng, Shu-Mei Gloria Chwo, Julia Chen, Dennis Foung, Vincent Lam and Michael Tom</td>
<td>884</td>
</tr>
<tr>
<td>Automatic Question Generation System for English Exercise for Secondary Students</td>
<td>Tasanawan Soonklang, Sunee Pongpinigpinyo, Weenawadee Muangon and Sirak Kaewjamnong Sugimoto</td>
<td>890</td>
</tr>
<tr>
<td>Student Engagement with an Online Preenrolment English Course at a Japanese University</td>
<td>Adam Smith and Andrew Johnson</td>
<td>896</td>
</tr>
<tr>
<td>Captioning Methods of Lecture Videos for Learning in English</td>
<td>Veri Ferdiansyah and Seiichi Nakagawa</td>
<td>902</td>
</tr>
</tbody>
</table>
Using Learning Analytics to Support Computer-Assisted Language Learning

Huiyong Li, Hiroaki Ogata, Tomoyuki Tsuchiya, Yubun Suzuki, Satoru Uchida, Hiroshi Ohashi and Shinichi Konomi

908

An Approach to Accent Visualisation for the Reduction of Vowel Pronunciation Errors

Tom Anderson, Barry Reynolds and David Powers

914

Chinese Grammatical Error Detection Using a CNN-LSTM Model

Lung-Hao Lee, Bo-Lin Lin, Liang-Chih Yu and Yuen-Hsien Tseng

919

Global Collaborative Learning Support System for Facilitator Collaboration: First Phase Development Report

Yoshiko Goda, Masanori Yamada, Yumi Ishige and Junko Handa

922

The Telexistence Robot combining Virtual Reality for Teaching English

Wen-Chi Vivian Wu, Tosh Yamamoto, Cheng-Hao Hu and Rong-Jyue Wang

925

Integration of Peer Assessment and Shadowing Strategies for Improving the Oral Performance of EFL Learners

Siao-Cing Guo and Ting-Chia Hsu

928

Effect Analysis of Students’ Learning Styles on Learning Experience with Lecture Videos Played at Different Playback Speeds

Toru Nagahama and Yusuke Morita

931

Word Error Rate as a Listenability Index for Learners of English as a Foreign Language

Katsunori Kotani and Takehiko Yoshimi

934

C7: Practice-driven Research, Teacher Professional Development and Policy of ICT in Education (PTP)

Full Papers

Science Teachers’ Engagement with ICT in Singapore: Different Perspectives

Aik Ling Tan and Seng Chee Tan

937

Participation and Psychological Ownership on Teachers’ Beliefs of a Cloud-Based VLE

Joanne Sau-Ching Yim, Priscilla Moses and Alia Azalea

946

A Learning Support Method to Raise Awareness of the knowledge-to-Action Gap in Information Ethics.

Koji Tanaka, Honomi Miwa, Mitsuru Ikeda and Masahiro Hori

955

An Empirical Study on the Influencing Factors of ICT Application: A Large Scale Survey for Middle and Primary Schools in China

Wei Wang and Chun Lu

965

PIVOTeeling: A Flipped Approach in a Postgraduate Solid State Devices Course

Lakshmi T G, Soumya Narayana, Harshavardhan Penugonda, Dhirendra Vaidya, Vishwendra Poonia, Swaroop Ganguly and Sahana Murthy

974

Short papers

Computational Thinking Development through Programmable Robotics Activities in STEM Education in Primary Schools

Siu-Cheung Kong and Chan-Chio Lao

984

Designing Mobile Applications for Improving Positive Behaviour for Learning (PB4L) Pedagogy

Lou Reddy and Nilufar Baghaei

990

Teachers’ Perception of IT in Science Education

Der-Thanq Chen and Wenjin Bo

996
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveying Indonesian Teachers’ Design Belief and TPACK for 21st Century Oriented Learning</td>
<td>Ching Sing Chai, Joyce Koh, Uma Natarajan, Pei-Shan Tsai, Murni Ramli and Ari Widodo</td>
<td>1001</td>
</tr>
<tr>
<td>Supporting Learning by Doing in a Work-process-oriented Curriculum</td>
<td>Yongwu Miao and Ulrich Hoppe</td>
<td>1007</td>
</tr>
<tr>
<td>Developing Pre-service Teachers’ 21st Century Teaching Competencies via Digital Storytelling</td>
<td>Wan-Lin Yang</td>
<td>1013</td>
</tr>
<tr>
<td>Current Situation of Chinese Primary and Secondary Innovative Teachers’ Evaluation in Maker Classes</td>
<td>Jun-Hao Shan and Shuai-Shuai Li</td>
<td>1018</td>
</tr>
<tr>
<td>Posters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students’ In-Class Answering Activities on Facebook: Effects on Participation, Learning Satisfaction and Anxiety</td>
<td>Yu-Hsin Liu and Fu-Yun Yu</td>
<td>1024</td>
</tr>
<tr>
<td>Student-Generated Feedback for Online Student-Generated Multiple-Choice Questions: Effects on Question-Generation Performance and Perspective-Taking Development</td>
<td>Fu-Yun Yu and Wan-Shan Wu</td>
<td>1027</td>
</tr>
<tr>
<td>Training System for Puncture Operation Force Adjustment in Hemodialysis</td>
<td>Ren Kanehira, Kazunori Yamazaki and Hideo Fujimoto</td>
<td>1030</td>
</tr>
<tr>
<td>Mobile Learning in Higher Education in Sudan</td>
<td>Adam Tairab, Huang Ronghuai, Mohannad Taha and Kirk Perris</td>
<td>1033</td>
</tr>
<tr>
<td>Close Reading of Science Texts with Online Annotations</td>
<td>Guillaume Schiltz, Sarah Frederickx and Norman Sieroka</td>
<td>1036</td>
</tr>
<tr>
<td>A Secular Trend Analysis of the Effects of Using ICT in University Education</td>
<td>Yasuhiro Tsuji, Rieko Inaba, Mieko Takahira and Mana Taguchi</td>
<td>1039</td>
</tr>
<tr>
<td>Early Career Research Paper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Role of a Technology and a Classroom Activity for Improving EFL Learners' Oral Performance</td>
<td>Kae Nakaya</td>
<td>1042</td>
</tr>
<tr>
<td>Author Index</td>
<td></td>
<td>1044</td>
</tr>
</tbody>
</table>
Designing the EMBeRS Summer School: Connecting Stakeholders in Learning, Teaching and Research

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Abstract: In this paper, we describe our research investigating design, teaching and learning aspects of the EMBeRS Summer School. In 2016, thirteen graduate Environmental Science students participated in a ten-day Summer School to learn about interdisciplinary approaches to researching socio-environmental systems. Using the Employing Model-Based Reasoning in Socio-Environmental Synthesis (EMBeRS) approach, students learned about wicked problems, team composition, systems thinking and modelling, stakeholder management, and communication. They applied this approach to their own research, as well as to a case study, in order to, ultimately, further the EMBeRS approach in their own institutions. Learning sciences researchers, environmental science instructors and learners collaborated in design, teaching, and learning during the 2016 Summer School in order to co-create and co-configure the tasks, social arrangements, and tools for learning, teaching and design. This paper identifies four examples of connections between the stakeholders (researchers, instructors and learners), the tools that facilitated the connection, and the implications for learning, teaching and design.

Keywords: interdisciplinary problem-solving, collaboration, learning, design

1. Introduction and Background

Learning, teaching, and design for learning have been conceptualised in terms of complex networks of learners, instructors, designers, and researchers, integrating physical and digital spaces (Howard & Thompson, 2016; Jacobson & Wilensky, 2006). To understand the relationships between design, teaching and learning, strong connections must be made between researchers and practitioners. This paper presents the application of a design-inquiry framework to analyse the Employing Model-Based Reasoning in Socio-Environmental Synthesis (EMBeRS) Summer School. It involved stakeholders in design, teaching and learning, and all contributed to the co-creation and co-configuration of the tasks, social arrangements, and tools for learning. Four examples of connections are presented: between researchers and instructors; instructors and learners; researchers and learners; and researchers, learners and instructors. The tools that facilitated each of these connections are discussed, and the implications for learning, teaching and design.

Synthesis, the act of integrating knowledge, data, methods, and perspectives in pursuit of a more comprehensive understanding, across disciplinary and professional boundaries is at the heart of addressing important socio-environmental issues. Many environmental science programs are functionally multidisciplinary and struggle to synthesize knowledge across disciplines (Vincent et al.,
Researchers, designers, instructors, and learners require guidance on how to more effectively accomplish their interdisciplinary goals, yet there is little evidence-based advice to be given beyond ensuring quality communication (O’Rourke et al., 2013). Methods for sharing knowledge in groups have previously been provided for group settings in professional fields (Brown, Lindgaard & Biddle, 2011), but little has been explicitly developed for interdisciplinary teams of scientists (Pennington, 2011). In such teams, this knowledge is complex, must be conveyed to team members with basic training in that field, and needs to be connected to achieve research outcomes that are truly synergistic.

Core to the development of EMBeRS was understanding the design of several common techniques of problem-solving and adapting elements of each to a socio-scientific context. Idea generation must be conducted in a way that ensures each idea is explained and all members of the group understand (Pennington, 2011). Time must be purposefully allocated for team members to try to make connections with their own research and generate novel, synergistic models of the problem (Fiore & Schooler, 2004; Pennington et al., 2016). Building on research from experiential learning theory (Kolb, 1984) and creativity (Brophy, 1998), three features of successful synthesis were identified: the ability to externalize one’s own disciplinary knowledge; promotion of active listening and individual reflection; and iterating between divergent and convergent thinking activities.

Model-based reasoning (MBR) is based on the concept that when faced with a problem-solving task, humans reason by constructing an internal mental model of the situations, events, and processes that comprise the problem, and that external representations can be used to facilitate construction of a mental model (Nersessian, 2009). MBR provides a cognitive explanation for boundary objects (Star & Griesemer, 1989) as key components that link across expert perspectives (Pennington, 2010). Pennington et al. (2016) identified the key stages of interdisciplinary problem-solving for socio-environmental synthesis as: (1) identifying an appropriate research question; (2) agreeing on a shared vocabulary; (3) co-creating boundary negotiating objects; and (4) deploying tools for visualizing and combining data, with the aim of (5) producing a new, connected model of understanding. The product of this negotiation is a model of the system under inquiry. Individual scientists contribute data to the model, building on their initial conclusions and further discussing the relationships between this model and other connected research.

Understanding the relationships between the components in a system of learning and design helps us to better understand why a design is successful, repeatable or transferable. We draw on the Activity Centred Analysis and Design (ACAD) framework (Carvalho & Goodyear, 2014) to map learning systems and design so that the activity of the learner is placed at the centre of the design. Research on the implementation of the EMBeRS approach with undergraduate students (Thompson et al., 2016) demonstrated the importance of considering the connections between the design, implementation and outcomes in order to inform redesign. We combined key concepts from design based research (Sandoval, 2014) and the ACAD framework to: organize multiple analytic techniques applied to complex datasets; allow tasks to be compared across learning settings; and connect design and theoretical assumptions with specific design decisions. (Figure 1). The designed learning environment encompasses multiple components of the learning environment: the digital and physical learning environments, tools, resources, as well as the tasks and social arrangements. Learner activity refers to the observable aspects of learner behaviour: their social interactions, how they approach and work through tasks, and how they communicate in talk and through the generation of written or computer-generated representations. The activity of the instructor is also important. Learning outcomes refer to measurable changes in learners over time.

Much of the recent discussion about multimodal data for learning (MMDL) has been reported in the context of multimodal learning analytics. In multimodal learning analytics, multiple types of data such as speech, text, handwriting, sketches, action and gesture, affective states, neurophysiological markers, and eye gaze (Blikstein & Worsley, 2016) are used to collect data about learner activity.
Research discusses how these data types can be connected, such as Thompson et al. (2013), and the importance of considering multiple dimensions of learner data to gain a more holistic understanding of learning activity (Blikstein & Worsley, 2016). Essential to considering MMDL is a way to organise, connect, and make decisions based on the results of analyses. Thompson et al. (2013) argue that the selection of data can be related to the ACAD framework.

2. Methods

The team implemented training activities during a two-week Summer School for PhD students, in July 2016, at the University of Texas at El Paso. The stakeholders included: seven instructors from the EMBeRS team (backgrounds in geological sciences, earth sciences, environmental science); guest instructors (specializing in systems thinking, stakeholder management); five researchers (backgrounds in science education, learning sciences, linguistics, learning analytics); and thirteen graduate students (six males, seven females). Graduate students were selected based on their disciplinary background (including environmental science and engineering; archaeology; bioengineering; urban management; ecosystem science and sustainability; agriculture and biological engineering; agricultural economics; water science and management; water resources), letter of recommendation from their advisor, the stage of their PhD, and their interest in interdisciplinary science.

The Summer School guided participants through lightly structured activities that employed the key phases of interdisciplinary problem-solving. At the end of each day, the group had explicit time for reflection on these activities, using the ACAD framework to guide student understanding of design choices, learner activity and learning outcomes, and each night they were asked to engage in individual reflections about their learning. In addition to the collaborative, discursive synthesis tasks, students were also given an individual, written synthesis task.

Participants were asked to complete an initial survey about their disciplinary background, educational experience and other background information. Design documents were prepared by members of the team, and their implementation recorded as the Summer School progressed. Audio recordings were collected, transcribed, and the discourse coded (using automated learning analytic techniques developed by team members) for convergence around ideas and language, and disciplinary knowledge. Video recordings were collected and the artefacts analyzed to identify the tools used. Interviews were conducted after the Summer School in order to obtain the participants’ perspectives on their gains in understanding and abilities and to evaluate the effectiveness of the different activities included in the school. Participants were asked to discuss what they learned, which activities were most helpful, how they intended to use their new knowledge and skills, and how the Summer School could be improved.

3. Results

The design of the Summer School and individual tasks was carried out by instructors and researchers over many months. The final design of the workshop was agreed upon, and transferred to a shared visual representation (Figure 2). Visualising the design of the Summer School allowed instructors to identify links could be made between individual tasks (e.g. Challenges of interdisciplinary work and Mock solicitation, Day 1), and repetition (e.g. Written reflections) and to manage tasks to be completed in students’ own time (e.g. Written reflections, Written synthesis). For researchers, visualizing the complexity of the design of the Summer School helped to guide the research questions and data collection, and ensure that appropriate data was collected to answer key research questions.

As can be seen in Figure 2, on most days there was a morning session (e.g. Toolbox project, Day 2), an afternoon session (e.g. Simplify with frameworks, Day 3), and tasks to be completed during the evenings (e.g. Written synthesis, Days 3, 5 and 8). Some tasks were repeated (e.g. Written reflection each evening) and others involved guest presenters (e.g. Simulation activity, Day 4). Each activity was also mapped using the combined design framework (Figure 1), identifying elements of the epistemic, social and set design and the design and learning conjectures. Figures 2b and 2c shows the design of two of the tasks designed for Day 1. The combined design framework provided an important link between researchers and instructors. The framework was used as a tool to prompt discussion and negotiation of
meaning around key terms. After each discussion, researchers better understood the design and learning intentions of the instructors. Instructors were able to articulate the assumptions that they made about learning and teaching, and conduct design of the tasks that ensured that epistemic, social and set elements were considered. Every task was visualized using the framework, which provided researchers with detailed representations of designed tasks that can be compared in future analyses.

Students were given multiple opportunities to practise the EMBeRS approach. Important features of the approach include active listening, and respect for different disciplinary approaches to solving problems. A strong culture of trust and a rhythm of communication developed between the instructors and the students. Multiple students wrote about trust particularly in their reflective tasks:

*The culture that has been established by the group was intentionally designed by the organizers of this workshop, and is one that creates a high level of trust, knowledge sharing, and respect. I believe that respect is at the center of the cultural values... The high level of trust can only be established in a safe space for talking and sharing your knowledge, where every member is supported, rather than judged. (Samantha, Day 4 reflection)*

This was most apparent during the tasks led by guest instructors, when it became obvious that the emergent practices of the group had not been communicated. This experience connected the instructors and learners in an unanticipated way.

*The culture that the group developed by using the EMBeRS model to communicate our ideas and bring them into a common space was readily apparent today when we introduced other members ... to the group dynamic via Skype. Because these people weren’t present in the room, and had not experienced the culture... communication with them during question and answer period was more strained. ... In other words, the trust that we developed during the previous days of the workshop had not yet developed. (Sandy, Day 4 reflection)*

Following this reflection, time was devoted to articulating the co-constructed group practices and the Summer School culture explicitly. Briefing of subsequent guests included introductions, a slower pace, and the provision of time for connections to be made in the co-creation of a shared model of understanding. It was empowering for the students to articulate and encourage these practices.
Researchers connected with learners in ways separated from the instructors. This was done through interviews at the end of the Summer School, and also tasks that students were asked to complete in the evenings (written reflections and synthesis tasks). During the interviews, most participants reported that they: learned skills to participate in and lead interdisciplinary/transdisciplinary teams (77%); gained an enhanced understanding of interdisciplinary/transdisciplinary research processes (69%); gained understanding of multiple perspectives/disciplines (62%), and learned to integrate disciplinary knowledge and methods using interdisciplinary modeling tools (54%). In a post-program survey asking participants to rate the effectiveness of each activity, almost all rated all the activities as of very high or high value. In addition to the written reflections, on three evenings, students were asked to write a synthesis of three articles, which had a shared theme (the water-food-energy nexus), each from a different disciplinary perspective. The students were first asked to draft a synthesis on Day 3 of the workshop, with opportunities on days 5 and 8 to redraft. While the interdisciplinary synthesis practices that were developed through discussion and co-creation of artefacts during the Summer School are important for an environmental scientist, the skills to synthesise and communicate different disciplinary knowledge in writing are also essential. The learners had the opportunity to engage in this practice, and to observe how their ability to connect disciplinary knowledge developed as they learned the group skills in parallel. The researchers analysed these syntheses with respect to their inclusion of topics or themes from the sources, intra- and inter-textual synthesis, evaluation, and sourcing (which articles were explicitly referred to). This analysis was conducted across all available drafts, to better understand the evolution of the synthesis over time. Across the texts produced, clear differences could be identified between students and over time, with students varying in the number of sub-topics or idea units expressed, the sourcing of these from the three documents, and their evaluation towards a particular conclusion.

The ACAD framework was used to guide group reflection at the end of each day. Students were asked to identify learning outcomes, and researchers suggested additional outcomes as relevant. Students then identified their activity, and the researcher outlined the design. The intention was for students to understand the purpose of the tasks they had participated in, for them to ask questions, and for them to make connections between what they were doing and what they were learning. For example, the overarching aim of all the tasks designed for Day 1 (Figure 2) was for students to gain experience in enacting the EMBeRS approach to solving problems. Learning outcomes were identified, including abilities to simplify thoughts about own research, communicate with non-experts, learn about different ways of representing, [develop] social capital, [identify] social implications, see interactions between research, and [realise] different programs experience with representatives. Only a subset of these identified learning outcomes aligned with those of the instructors. The guided reflection was beneficial for both instructors and students. For students, it scaffolded the connection of tasks within a day, or between days, with the overall learning goals. The process also allowed the instructors to reflect on whether the design and learning intentions of each day were met, and to make adjustments to the design of the tasks on subsequent days to ensure that any misalignment was corrected.

4. Discussion and Conclusions: Implications for design, research and learning

Many changes were made for the 2017 Summer School based on the analysis presented above. Two main changes reflect the importance of designing for the co-creation of an environment for learning in which instructors, researchers, and learners can connect, trust and build a collaborative culture as well as models of understanding. The timing of the Summer School was chosen to ensure that more of the instructors could be present in person, and the ‘share your research’ task on the first day was extended to ensure that all students have the opportunity to work together. This tests the design conjecture: more time will enable the culture to be co-created and co-configured. The ultimate aim of the research is to generate new insights into effective synthesis practices. These insights will enable synthesis decision-makers (by which we mean research team leaders, learners, instructors, and program designers) to make informed decisions about designing and engaging in synthesis activities. The multimodal dataset captured the activity of learners, over time, as participants learned to identify and represent their own disciplinary knowledge; collaborate in an interdisciplinary team; and allow a shared problem model to emerge. Further analysis of the dataset is focused on identifying evidence of
disciplinary knowledge, interdisciplinary knowledge (the shared 'language'), and collaboration, and relating these to the design of tasks and instructional practices.

Given the complexity of the design of the EMBeRS Summer School, there were numerous learning objectives related to individual tasks, as well as the Summer School overall. One of the implications of using the ACAD framework is the importance of observing the co-creation and co-configuration of learning. Learners were given access to the design intentions every day (through the guided reflections), and developed relationships with the researchers and the instructors. They became important stakeholders in their own learning, and had significant power in that relationship. A follow-up survey has revealed that many of the participants have applied what they learned during the Summer School to planning the next stages of their dissertation with their advisors. They have also been using elements of the approach in professional settings including the design of workshops, presentations, and other interdisciplinary research. The tools used (the ACAD framework) as well as the social relationships (with researchers and instructors), and the development of a shared culture, were as important as the designed tasks in enabling these students to co-create and co-configure their learning.

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