Inquiry-based cell culture course improves student conceptual and practical understanding of biomedical research

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Introduction

Course goals

- Develop strong scientific thinking abilities in the context of cell biology experimentation
- Train students in cell culture methods through inquiry-based activities
- Engage students in a research-like experience

Course modules

- Cell Proliferation
  - NIH 3T3 cells used to examine the contribution of sera and substrates to the rate of cell proliferation
- Cell Viability
  - NIH 3T3 cells used to test the cytotoxic potential of various additives
- Cell Differentiation
  - Adipose derived mesenchymal stem cells (AD-MSCs) used to examine their multipotent differentiation capacities: adipogenesis, osteogenesis, chondrogenesis

Lab intensive course implementation

- Flipped classroom model
  - Content delivery via textbook and course materials posted to Blackboard
  - In class activities are mainly development of culture skills and experimentation (groups of 2-4 students)
- Testing
  - On-line: pre-class quizzes, illustration of protocols and experimental designs
  - In class: three written examinations and one laboratory practicum

Course assessment

- Pre- and post-course self-efficacy and career aspirations surveys
- Experimental Design Ability Test (EDAT)

Acknowledgments

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Examples of Student Experimental Data

Cell Proliferation

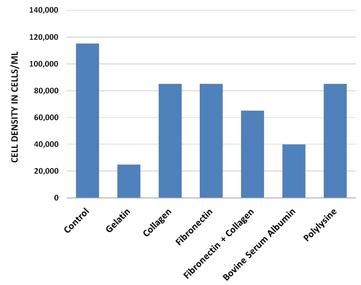

Figure 1. NIH 3T3 cell proliferation on various substrates. Cells seeded at 1.5 x 10^4 cells/ml were cultured in DMEM with 10% FBS. After 7 days, cells were counted and cell density calculated.

Cell Viability-Live/Dead

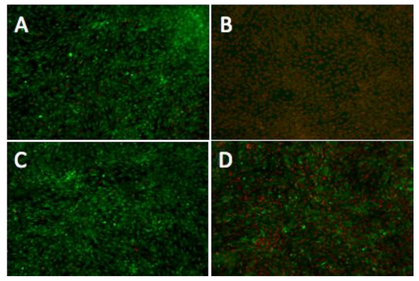

Figure 2. Effect of melatonin on NIH 3T3 cell survival. Cells were cultured for 2 days in DMEM with 10% FBS before adding 0.2 mM (C) or 2 mM (D) melatonin in the medium. Live/Dead assay was performed 2 days post-treatment. (A) No melatonin treatment, (B) 70% methanol killed cells.

Cell Viability-Alamar Blue

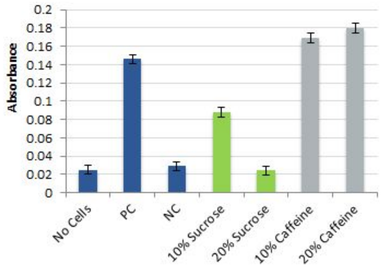

Figure 3. Effect of sucrose or caffeine on NIH 3T3 cell survival. Alamar blue assay performed after culture in DMEM with 10% FBS and 83.3mM sucrose (10%), 166.6mM sucrose (20%), 8.3mM caffeine (10%) or 16.6mM caffeine (20%). PC: positive control; NC: negative control, methanol-killed

Cell Differentiation

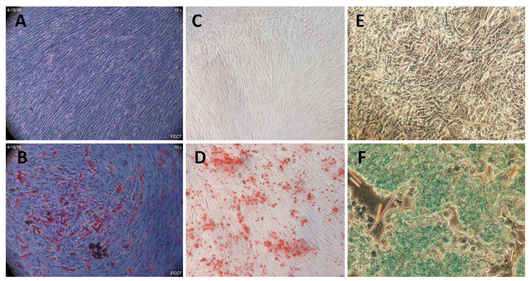

Figure 4. Differentiation of adipose-derived mesenchymal stem cells (AD-MSCs). Adipogenesis: A) Oil red O staining of undifferentiated cells, B) Oil red O staining of differentiated cells (red lipid droplets). Osteogenesis: C) Alizarin red S staining of undifferentiated cells, D) Alizarin red S staining of differentiated cells. Chondrogenesis: E) Alcian blue staining of undifferentiated cells, F) Alcian blue staining of differentiated cells.

Course Assessment

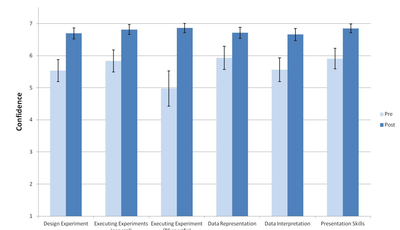

Figure 5. Student-reported confidence in various clusters of inquiry-based scientific skills. Final scores were derived from the averages of student responses (1-7 Likert scale) to questions assigned to each cluster on a survey administered before taking the course (pre) and after completing the course (post). Error bars represent 95% confidence intervals.

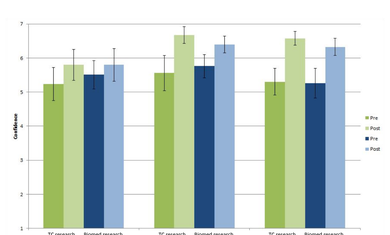

Figure 6. Student-reported interest, capability, and understanding of tissue culture and biomedical research. Final scores were derived from the averages of student responses (1-7 Likert scale) before taking the course (pre) and after completing the course (post). Error bars represent 95% confidence intervals.

Discussion

- Self-efficacy and career aspirations surveys show a positive effect on the students' confidence
- Students indicate a better understanding of biomedical and cell culture research and a slight increase in their interest in these areas
- Post-course evaluation of experimental design ability did not demonstrate significant improvement.

Future Directions

- Assessment of experimental design ability in the specific context of cell biology
- Development and assessment of new modules to teach
  - flow cytometry
  - gene expression analysis
  - primary explant culture