International Conference
The Future of Education

Stories of Active Learning in STEM: Lessons for STEM Education

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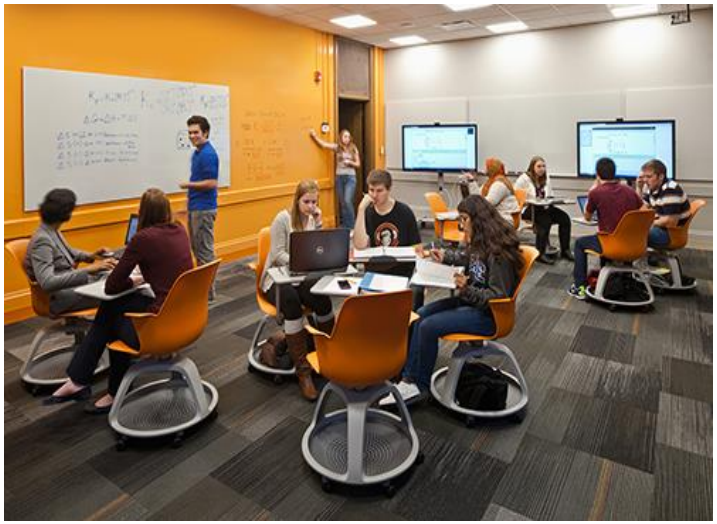
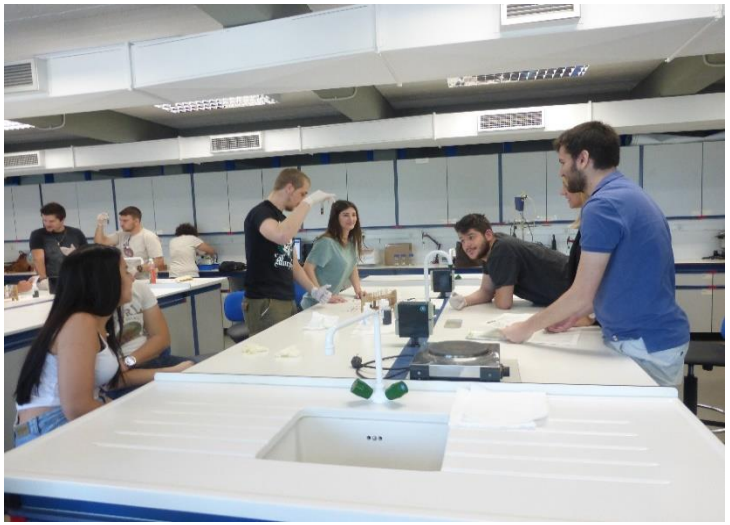
Introduction

- Active vs. passive learning
- Active learning:
  - student-centered learning
  - "Students do things and think about what they are doing" (Bonwell and Eison, 1991)
  - Examples
    - Class discussion, question-and-answer
    - Role playing, peer teaching, flipped lessons



from www.case.edu



Introduction

- Challenges of teaching in STEM education
  - Breadth vs. depth
  - Stimulate student engagement
  - Can students develop responsibility as learners?
  - Can they participate in the construction of knowledge?
  - Can they challenge mainstream thinking?

Introduction

- The need for a new approach to learning in the sciences has been emphasized in the last decades.
  - Students seek new knowledge, re-organize it, explain it to others (Huba and Freed, 2000)

- Does active learning help in STEM disciplines?
  - Active learning in STEM was shown to:
    - Increase student performance
    - Improve students' attitudes

- Active Learning empowers students
  - Students develop responsibility and learn to challenge taken-for-granted knowledge

Aim

- The aim of this paper is to
  - Identify effective teaching strategies that promote active learning in STEM.
  - Provide a guide for future studies on active learning in STEM.

Methodology

- Five undergraduate courses in STEM disciplines were selected.
  - three in science, one in math, one in information technology
- Instructor feedback was provided through an open-ended questionnaire; five narratives were produced ("stories")
- Analysis, discussion and conclusions followed.

How the Five Instructors Define Active Learning

Course	Definition of Active Learning
Case A (Environmental Science)	**Learner-centered**; learning by experience and by "doing"; various in-class activities
Case B (Biology)	More focus on developing student understanding and other skills; **problem-based**, interactive, **collaborative** and **cooperative** learning
Case C (Greening the Campus)	**Learner-centered**; students are involved in the learning process; instructor acts as mentor and facilitator; experiential and **action-based** learning
Case D (Mathematics for Business, Economics and Sciences)	**Learner-centered**; instructor acts as facilitator to actively engage students throughout the learning process
Case E (IS for Decision Making)	Engage students in the exploration of knowledge; **critical problem solving**; personal and **team skills development**

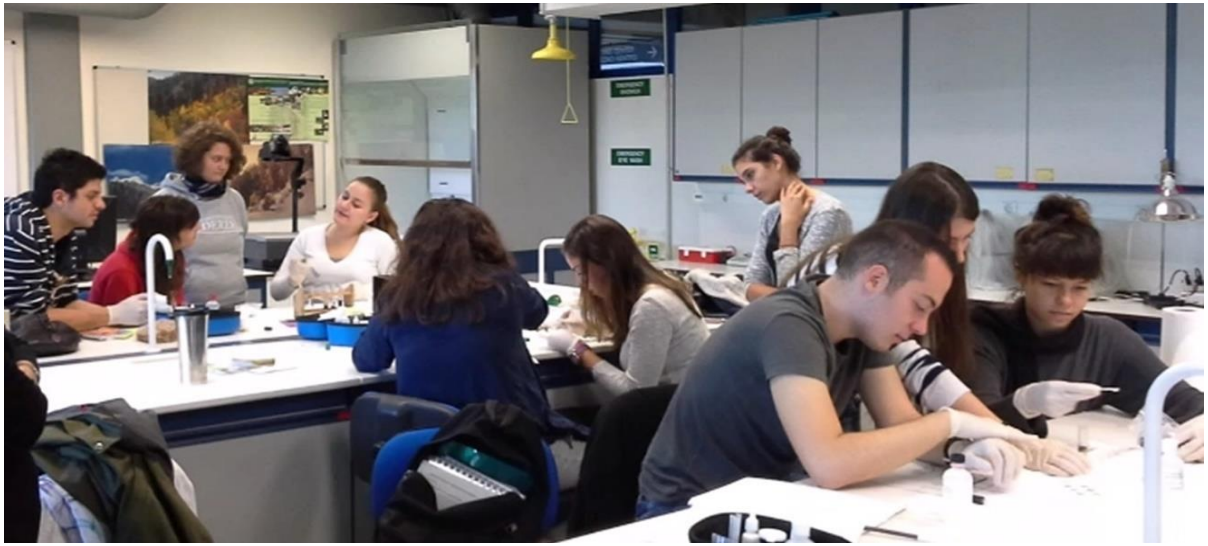
Stories of Active Learning: Environmental Science (Case A)

Case A	Environmental Science
Specific Goals for the course	• Transmission of **knowledge** (achieve scientific literacy); **critical evaluation**, **analysis**, **application to everyday life**; • Develop **practical and transferable skills** (including teamwork and scientific writing)
Active Learning Methods used	• Question and answer • Brainstorming and class discussion • In-class debate • Lab and field activities involving team work • Lab reports • Group discussion based on video screening • Pause and in-class summaries • Online technologies (Use of Blackboard for course information and material, instructor feedback, discussion boards, interaction with instructor and class mates, feedback on assignments)

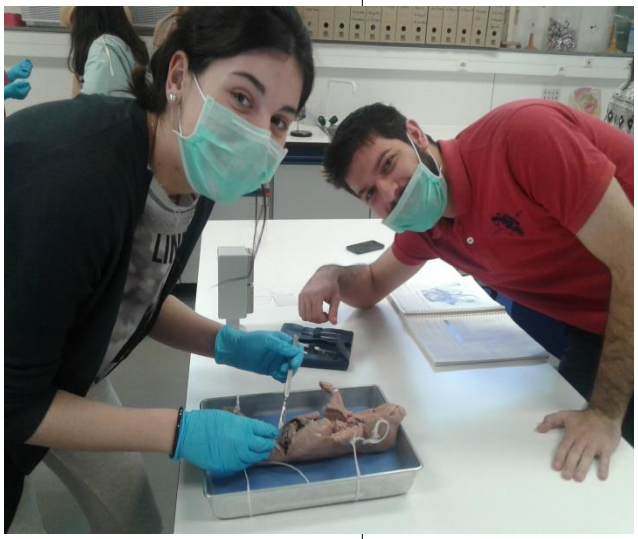
Stories of Active Learning: Biology (Case B)

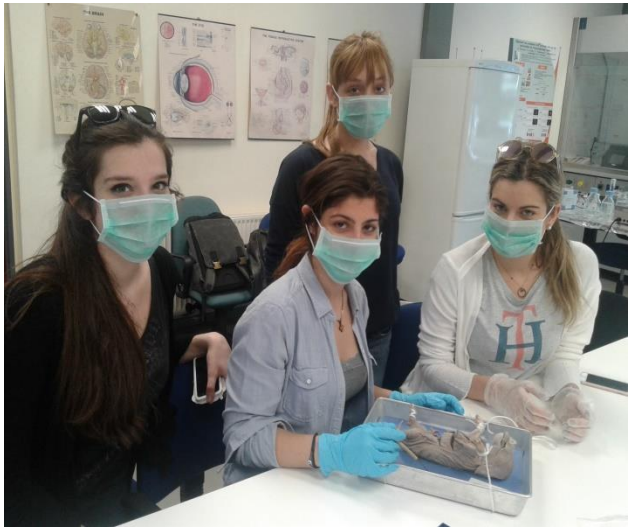
Case B	Biology
Specific Goals for the course	• Transmission of **knowledge** (biology from human perspective); **critical evaluation**, **analysis**, **applications** (connections with life and society) • Develop **practical and transferable skills** • Stimulate interest using **digital and modern pedagogical approaches**
Active Learning Methods used	• Question and answer • Class discussion • Lab activities involving team work • Student companion site of the textbook • Online technologies (Use of Blackboard and of the online resources of the textbook for information, material, online quizzes and questions, animations, audio and visual material, virtual labs)

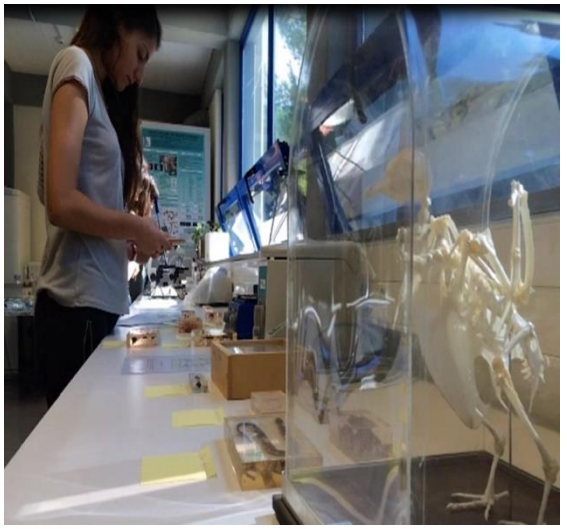
Stories of Active Learning: Lab Activities



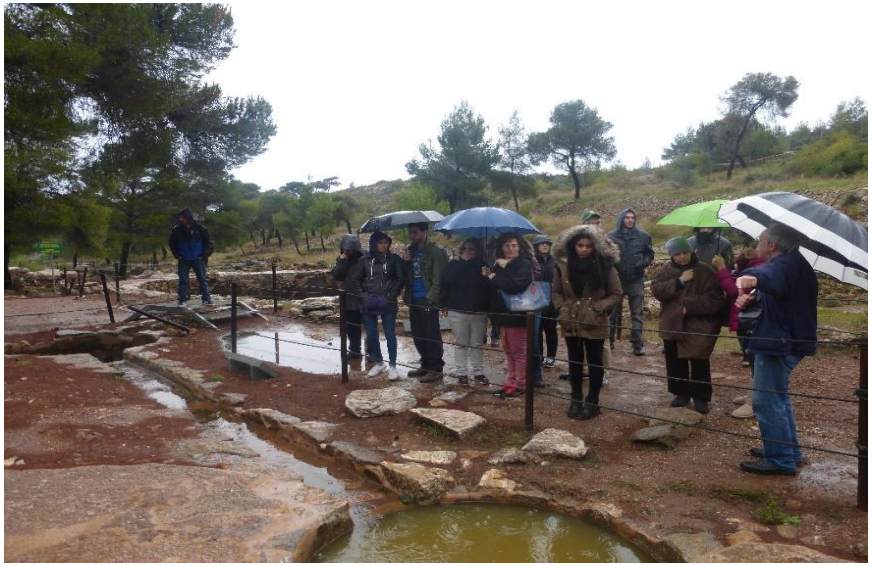
Lab Activities: Environmental Science, Biology







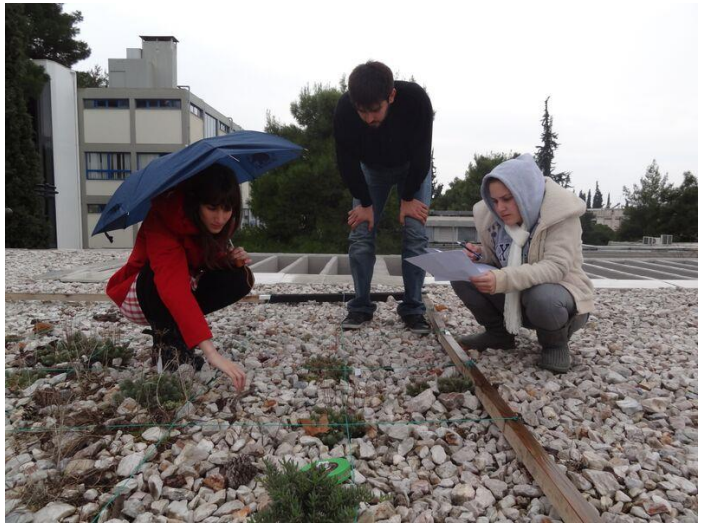
Stories of Active Learning: Field Activities and Visits

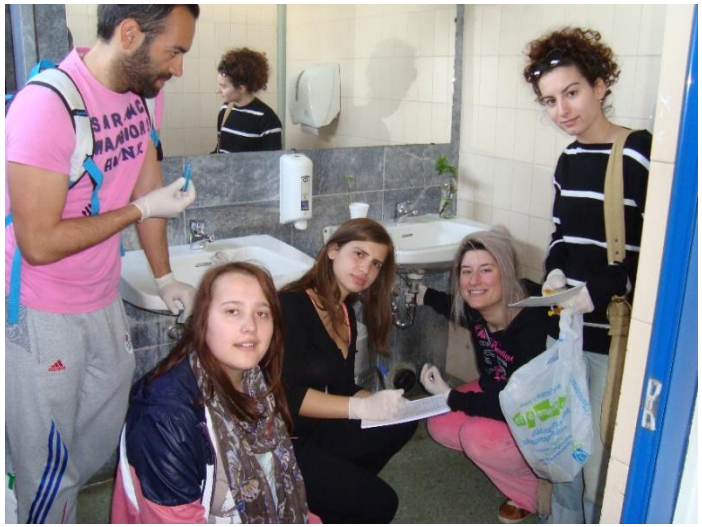


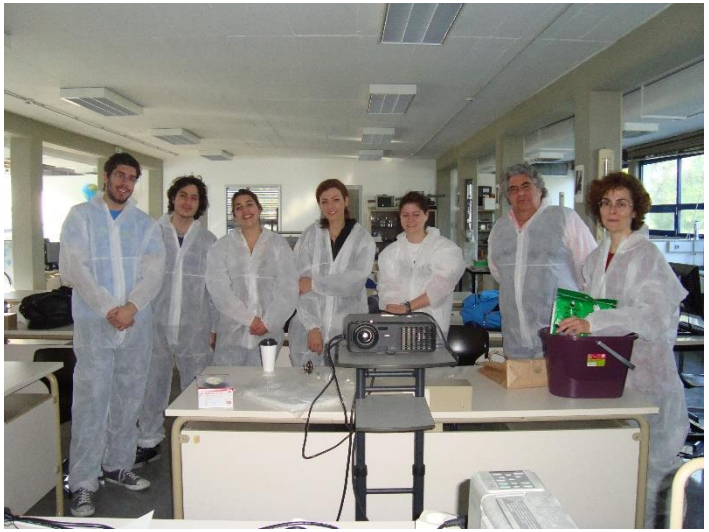
Stories of Active Learning: "Greening the Campus" (Case C)

Case C	Greening the Campus
Specific Goals for the course	• Help students develop **ownership of basic knowledge**; develop **critical thinking** about generally accepted knowledge in a subject matter • Provide opportunity for **collaboration of faculty with students on campus issues**; **experiential learning**; **action research**
Active Learning Methods used	• Field activities, lab activities and visits • Group project involving field and lab work, data collection, analysis and final report • Collaborative learning through group work in field projects, creative projects and interviews; game • Portfolio with essays and journal entries • Creative project • Online technologies (Use of Blackboard for course information and material, instructor feedback, discussion boards including group discussion boards, interaction with instructor and class mates)

Stories of Active Learning: Experiential Learning and Action Research



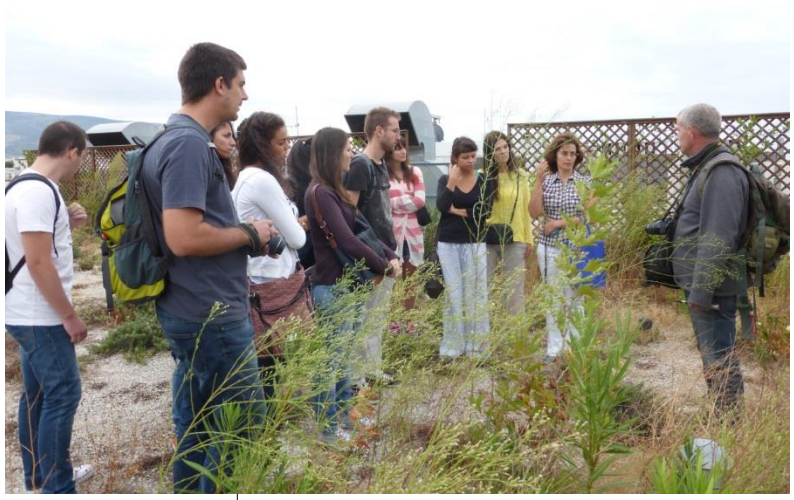


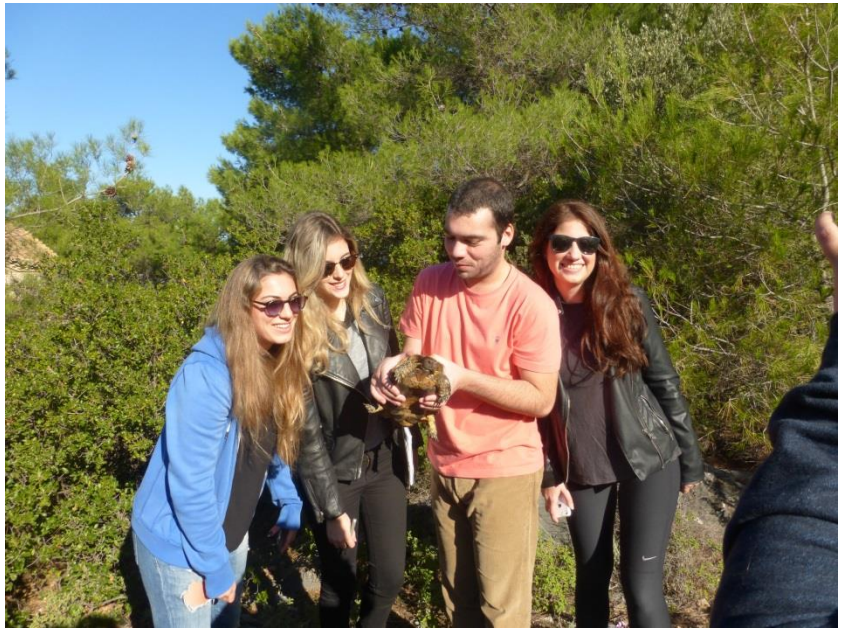


Activities from Greening the Campus

Stories of Active Learning

Activities from Greening the Campus





Stories of Active Learning: Mathematics (Case D)

Case D	Mathematics
Specific Goals for the course	• **Understanding** of quantitative information; **application** in and outside their discipline; **application to real- life word problems** • opportunities for **authentic learning using different active learning methods**
Active Learning Methods used	• Flipped classroom (students watch videos w. lecture and exercises at home) • Question and answer • Class discussion • Mini-lecture with pause • Problem solving with think-pair-share • Collaborative learning through in-class team work (think-pair-share) • Instructor feedback on assignments • Online technologies (Blackboard with access to course information and material; survey tool of Blackboard was used for a survey)

Stories of Active Learning: Information Technology (Case E)

Case E	Information Systems
Specific Goals for the course	• Transmission of **knowledge**, ability for **communication**, **critical thinking** • Development of **research skills** (knowledge management and decision making). • **Connection with real life and real world problems**
Active Learning Methods used	• Case studies requiring a multidimensional analysis • Class discussion • Collaborative learning (sharing of resources and ideas; collaborative development of students' research model on Knowledge Management; feedback from instructor at various stages of the project) • Online technologies (Use of online platforms for collaborative work; use of knowledge mapping tools)

Instructors' Perception of Active Learning

- Instructors' definition of active learning shows similarities and differences (table 1)

  -learner-centered

  -problem-based

  -action based; experiential

  -collaborative

  -focusing on the development of skills other than knowledge

Teaching Goals and Teaching Strategies

- Comparison of teaching goals
  - All aimed at knowledge, understanding, but also at developing skills for critical evaluation, analysis, application and connection with real world cases.
  - Three courses aimed directly at the development of teamwork skills
  - One course aimed at the development of research skills
- All teaching strategies were connected with the learning outcomes and the teaching goals for the course.
- Assessments were also designed to test learning outcomes and meet teaching goals.

Student Learning: Effective Teaching Strategies (1)

- Level of engagement and autonomy of students plays a role.
  - **Group field project** (Case C) and **flipped classroom** (Case D) promoted more student autonomy.
  - In science courses (Cases A, B and C), **lab activities and lab reports** also involve high level of student engagement and help students gain practical and transferable skills (teamwork, scientific writing)
  - Prior exposure to similar material seems to increase the level of engagement and autonomy (Cases A and B)

Student Learning: Effective Teaching Strategies (2)

- A combination of different active learning methods can prove effective.
  - In the math class (Case D), the combination of methods used (flipped lessons with follow-up in-class activities) affected positively both students' perception of the course and student learning, as assessed by a survey.
  - In the Information Systems class (Case E), class discussions, case study analysis and student project presentations produced learning and enhanced student research skills.

Student Learning: Effective Teaching Strategies (3)

Other observations made

- In-class debate and group discussion after video screenings helped resolve misconceptions on environmental issues.
- Journal entries encouraged freedom of expression and stimulated emotions.
- Group discussion boards became an effective communication tool among groups.
- Online tools (quizzes, animations, discussion boards) helped the students who engaged with them.

Challenges – Issues to Consider

- Level of course
- Composition of student population (age, educational and cultural background, major)
- Achieving depth without sacrificing breadth
- Time management
- Classroom management
- Maintaining student motivation and engagement

Conclusion

- Different teaching strategies prove effective for different STEM courses depending on course goals.

- More systematic evaluation of active learning strategies needed
  - student and instructor surveys
  - student performance
  - instructors' conceptions of effective teaching

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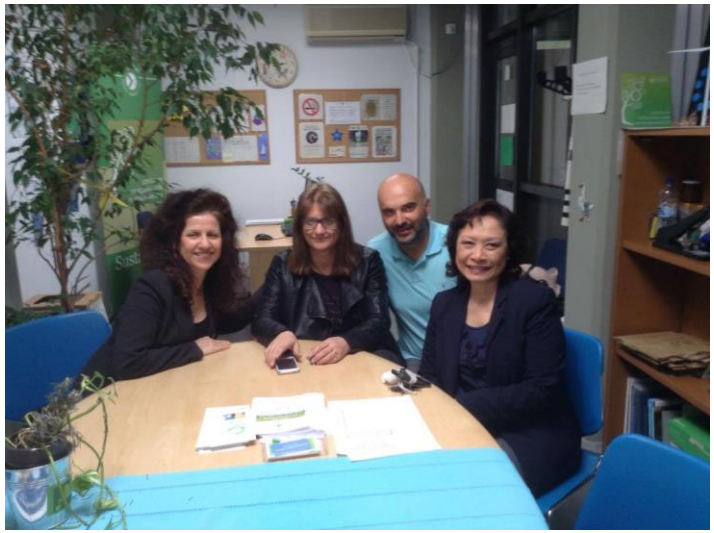
THANK YOU!



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