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Best Practices in STEM Education: Using Active Learning and Novel Teaching Methodologies for Sustainable and Innovative Education

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ABSTRACT: In our days there is a critical debate for the effectiveness of Science, Technology, Engineering and Math (STEM) Curricula and their revision based on flexible active learning didactical approaches. From various sources, it is evident that there is a critical gap in the perception of students and academic directors for the need of STEM education. In our research work we provide a methodological approach that communicates some critical actions required for the integration of STEM Curricula in modern academic programs.

The core knowledge in STEM curricula requires a detailed analysis of effective didactics and teaching methods. The current problems in the effectiveness of teaching in STEM curricula are related to the diffusion of the learning content and the facilitation of an active learning environment. A detailed desktop literature research provides the input of our methodological approach. We analyzed the literature related to gaps in STEM Education, teaching performance and we informed a research model comprising of critical success factors. These were used in a meta-analysis through a qualitative research facilitated with interviews of STEM Professors from 14 countries. The basic focus of our analysis is the role of Active Learning, Technology enabled teaching Methodologies and Social Networks as a key response to the need for effective STEM Education.

The main findings are related to design guidelines for New STEM Education programs, Technology Related Success Factors and Active Learning Strategies. The integrative approach of Active Learning, Technology driven learning innovation and Teaching Strategies for Stem is inevitable for the next generation STEM education, where critical Learning Objectives should be reconsidered and integrated with Portfolios management of students.

Our research also provides critical guidelines for Program Directors of Colleges and Universities for reconsidering the priorities. One of our key conclusion is that investment in STEM education is a key response in order to foster Innovation and Sustainability.

OUTLINE OF TALK

- Background
- The STEM experience
- Focus and Goals
- Evaluation of past teaching methods
- Critical gap in the perception of students and academic directors for the need of STEM education
- Proposal of new flexible active learning didactical approaches
  - ➢ Active learning
  - ➢ Origins of active learning and PBL in STEM
  - ➢ Use of ICTs in active learning
  - ➢ Problem-based learning (PBL)
- Analysis of effective didactics and teaching methods
- Literature analysis related to gaps in STEM Education
- Meta-analysis through a qualitative research facilitated with interviews of STEM Professors from 14 countries.
- Critical actions required for the integration of STEM Curricula in modern academic programs.
- Investment in STEM education as a key response in order to foster Innovation and Sustainability.

FOCUS AND GOALS

- The basic focus of our analysis is the role of Active Learning, Technology enabled teaching Methodologies and Social Networks as a key response to the need for effective STEM Education.
- To help design guidelines for New STEM Education programs.
- To propose the integrative approach of Active Learning, Technology driven learning innovation and Teaching Strategies for Stem as inevitable for the next generation STEM education, where critical Learning Objectives should be reconsidered and integrated with Portfolios management of students.
- Demonstrate techniques & activities using also ICT in STEM education.
- Incorporate active learning into our future teaching
- To provide critical guidelines for Program Directors of Colleges and Universities for reconsidering the priorities.
- One of our key conclusion is that investment in STEM education is a key response in order to foster Innovation and Sustainability.

1. Critical Success Factors of STEM Education

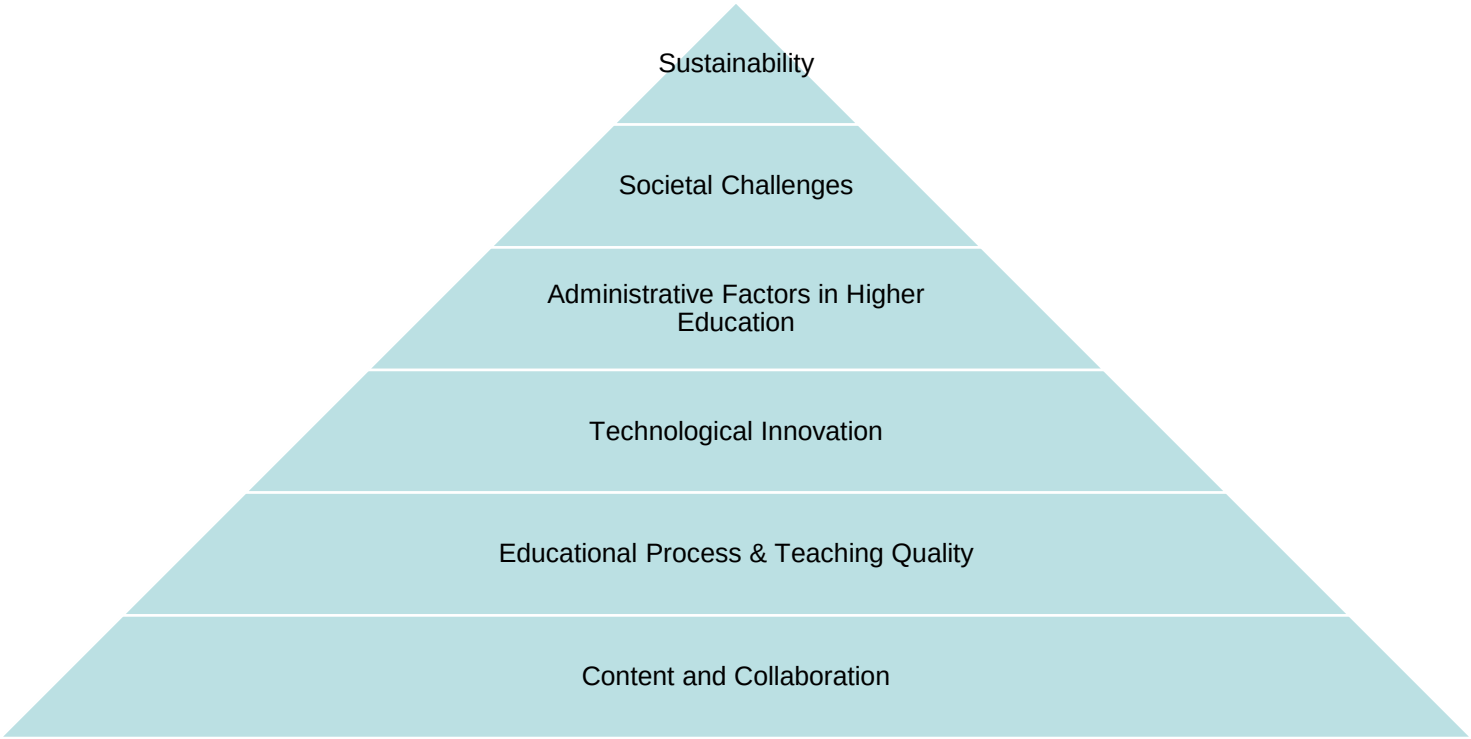

Fig. 1. Aspects of STEM core competencies

Content and collaboration

- Design of Learning Content
- Modularization of Content provision
- Evidence Based Content
- Experimentation
- Theory and Practice Integration
- Community Based Content Creation
- Open Resources
- Lessons Learnt and Best Practices
- Flexible Adoption

Educational Process

- Personalized Learning
- Active Learning
- Evidence Based Learning
- Critical Skills development
- Continuous Improvement
- Collaborative Learning
- Special Needs
- Educational Laboratories
- Conceptual Modeling

Administrative Factors

- New Areas for Development
- Designing of Timely Curricula and Programs
- Interdisciplinary Integration
- Resources Management
- Holistic Evaluation
- Management by Objectives

Technological Innovation

- Integration of Novel Information and Communication Technologies
- Technology Enhanced Learning
- Free and Open Source Tools
- Massive Open Online Courses
- Emerging Technologies Exploitation (Cloud Computing, Big Data, Virtual Reality, Games and Simulations]
- Industry Academia Collaborations [Startups, Competitions, Awards]
- Cognitive Computing

Societal Challenges

- Green Economics
- Social exclusion
- Development and Prosperity
- Integration of STEM Outcomes to Society
- Economic austerity
- New Business Models
- Environmental problems

Sustainability

- Balance between / integration of environmental – social – economic aspects
- Continuous Improvement and longevity
- Community - Industry - Academia Partnerships
- Research Enhancement
- New Knowledge for social innovation
- Performance based on integration of knowledge and affect

2. An integrative methodological framework for effective STEM education

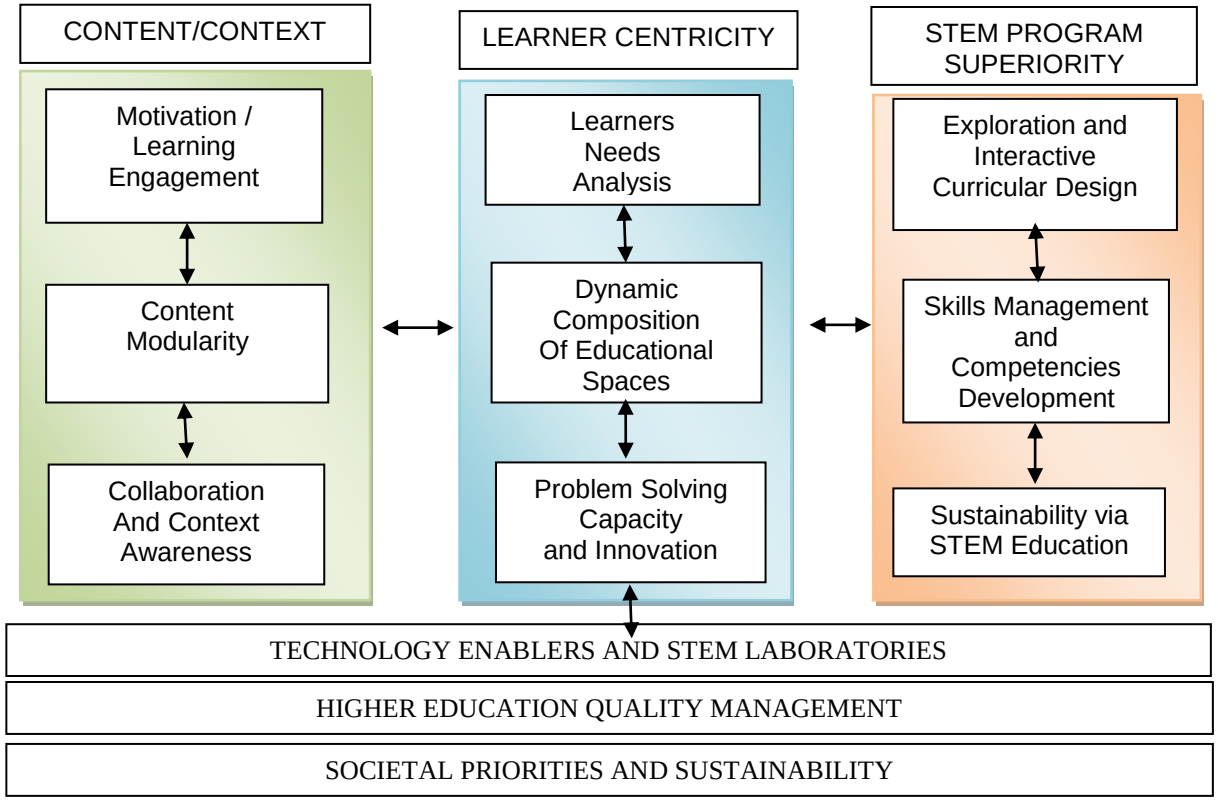

Figure 2. An integrative research model for hermeneutic factors of STEM education excellence

Scenario/ Strategy	Novel Learning/ Teaching Methodologies	Content/ Context Awareness	Learning Technologies	STEM for Innovation & Sustainability
A.	Group Learning	Content Discovery	Collaborative Platforms	Social responsibility
B.	Exploratory Learning	• Open Educational Resources	• Question and Answering Systems • Collaborative Filtering Platforms • Social Networks	• Innovation with a purpose
C.	Concept Modeling / Associations	• Industry Driven Requirements • Literature Studies	• Concept Maps Software	• Integration and multidisciplinarity
D.	Synthesis and Analysis	• Conceptual Modeling • Interdisciplinary integration	• Question Answering Systems • Recommender Systems	• Experiential learning • Critical study • Real problem solving
E.	Active Learning	• Engagement based on personal needs • Profiling	• Educational Games • Simulations • Virtual Reality Environments • Labs • Haptic Technologies • Dynamic Profiling • Recommender Systems	• Experiential learning • Action research • Lab activities • "Green" design
F.	Capstone Mentoring	• Research Based content • Problem Solving • Research Models review	• Research Software • Groupware • Cloud Shared Applications • Brainstorming tools	• Action research • Field work • Problem solving
G.	Peers Mentoring	• Peers Profiling, Skills Profiling	• Collaborative Platforms • Workflow Systems	• Group work & collaboration

Table 1. Model for design of STEM education programs

Future Research and Conclusions

The next steps in our research include four major research initiatives:

- An empirical study related to the perceptions of qualitative factors in STEM education programs. This is going to run in summer 2016. The main focus of the study is to reveal connections between the hermeneutic factors presented in the previous section
- A focused study on dimensions of Active Learning and Teaching Strategies
- The design of three pilot courses integrating the key propositions of our research
- The preparation of a project proposal for Active Learning for STEM education

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