Visualizing the future of education through digital 3D technologies

http://lingid.ee/Leo3D

Leo Siiman
Senior Research Fellow of Technology Education
Centre for Educational Technology
Institute of Education, University of Tartu, ESTONIA
http://haridustehnoloogia.ut.ee

Research seminar
Institute of Informatics, Tallinn University
February 4, 2015

Outline

- Who am I? What is my background?
- What am I doing at the University of Tartu?
- Why are new 3D technologies important for teachers and education?
- What significant research questions related to 3D technologies should be investigated in education research?

Who am I?

BA Computer & Electrical Engineering, 1997-2001

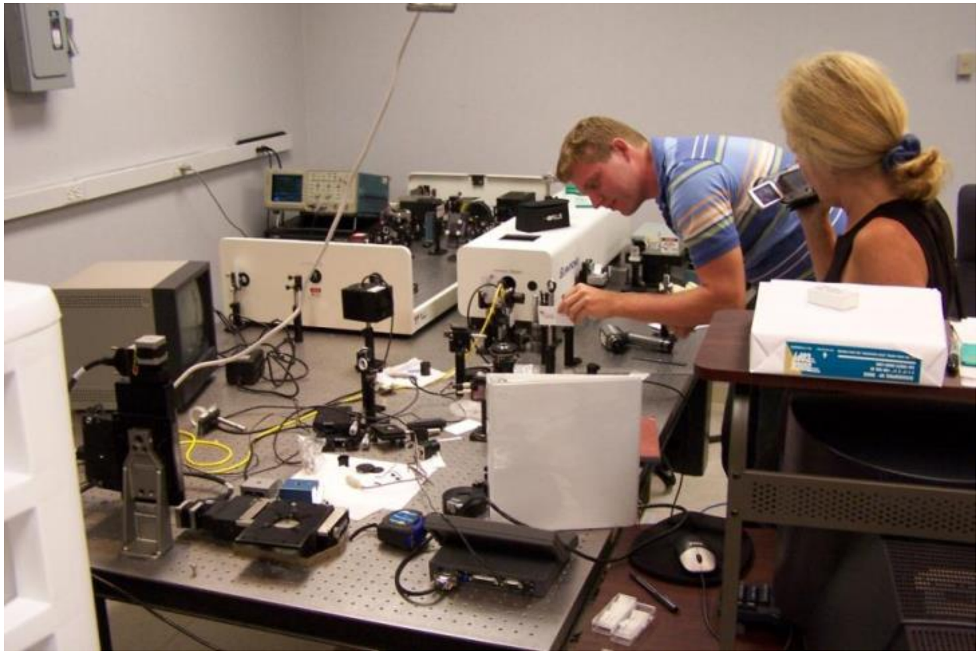
University of Florida

Who am I?

BA Computer & Electrical Engineering, 1997-2001

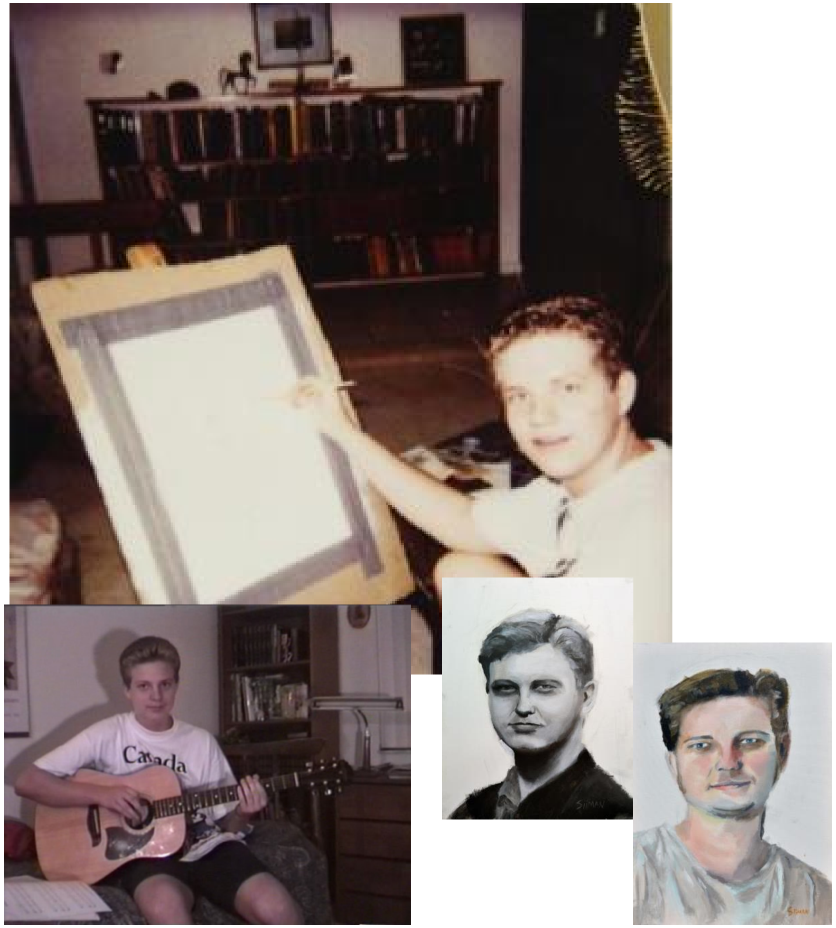
PhD laser physics, 2003-2008

University of Florida

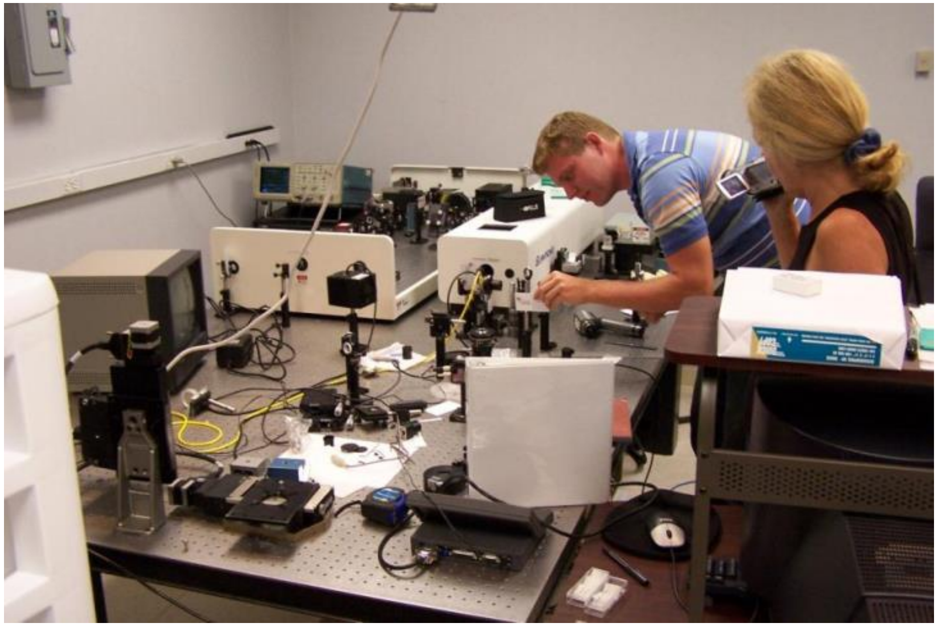


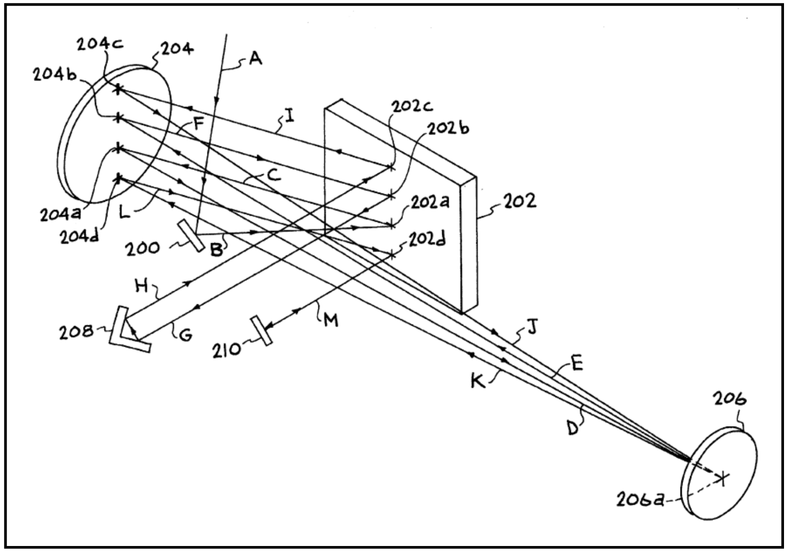
Laser Institute, Orlando, Florida

Creative hobbies

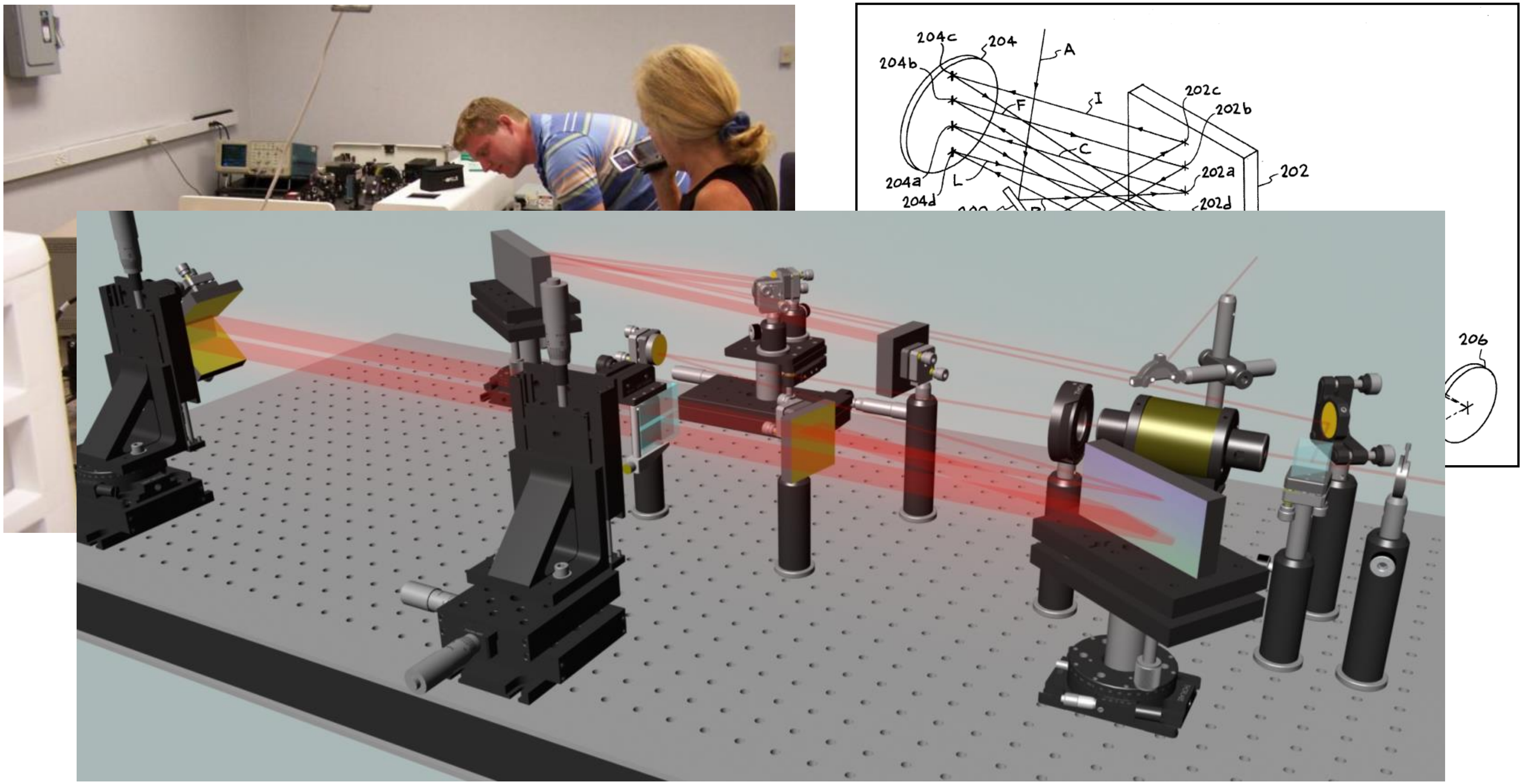


Complex laser experiments

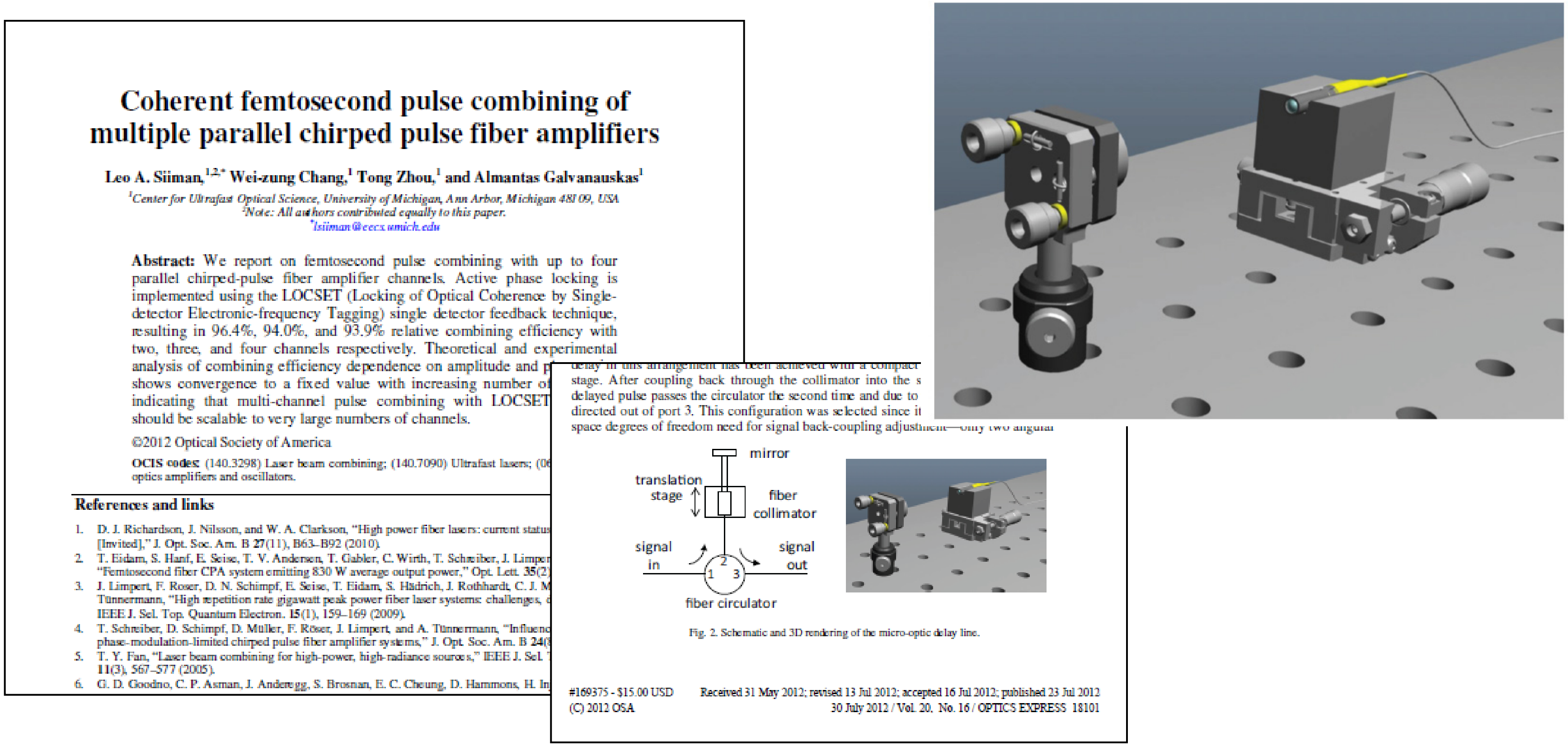




Complex laser experiments



Communicating ideas



Coherent femtosecond pulse combining of multiple parallel chirped pulse fiber amplifiers

Leo A. Siiman,[1,2,*] Wei-zung Chang,[1] Tong Zhou,[1] and Almantas Galvanauskas[1]
[1]Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, Michigan 48109, USA
[2]Note: All authors contributed equally to this paper.
*lsiiman@eecs.umich.edu

Abstract: We report on femtosecond pulse combining with up to four parallel chirped-pulse fiber amplifier channels. Active phase locking is implemented using the LOCSET (Locking of Optical Coherence by Single-detector Electronic-frequency Tagging) single detector feedback technique, resulting in 96.4%, 94.0%, and 93.9% relative combining efficiency with two, three, and four channels respectively. Theoretical and experimental analysis of combining efficiency dependence on amplitude and p shows convergence to a fixed value with increasing number of indicating that multi-channel pulse combining with LOCSET should be scalable to very large numbers of channels.

OCIS codes: (140.3298) Laser beam combining; (140.7090) Ultrafast lasers; (06 optics amplifiers and oscillators.

References and links

1. D. J. Richardson, J. Nilsson, and W. A. Clarkson, "High power fiber lasers: current status [Invited]," J. Opt. Soc. Am. B 27(11), B63–B92 (2010).
2. T. Eidam, S. Hanf, E. Seise, T. V. Andersen, T. Gabler, C. Wirth, T. Schreiber, J. Limper "Femtosecond fiber CPA system emitting 830 W average output power," Opt. Lett. 35(2)
3. J. Limpert, F. Roser, D. N. Schimpf, E. Seise, T. Eidam, S. Hädrich, J. Rothhardt, C. J. M Tünnermann, "High repetition rate gigawatt peak power fiber laser systems: challenges, IEEE J. Sel. Top. Quantum Electron. 15(1), 159–169 (2009).
4. T. Schreiber, D. Schimpf, D. Müller, F. Röser, J. Limpert, and A. Tünnermann, "Influenc phase-modulation-limited chirped pulse fiber amplifier systems," J. Opt. Soc. Am. B 24(
5. T. Y. Fan, "Laser beam combining for high-power, high-radiance sources," IEEE J. Sel. 11(3), 567–577 (2005).
6. G. D. Goodno, C. P. Asman, J. Anderegg, S. Brosnan, E. C. Cheung, D. Hammons, H. In

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delay in this arrangement has been achieved with a compact stage. After coupling back through the collimator into the s delayed pulse passes the circulator the second time and due to directed out of port 3. This configuration was selected since it space degrees of freedom need for signal back-coupling adjustment—only two angular

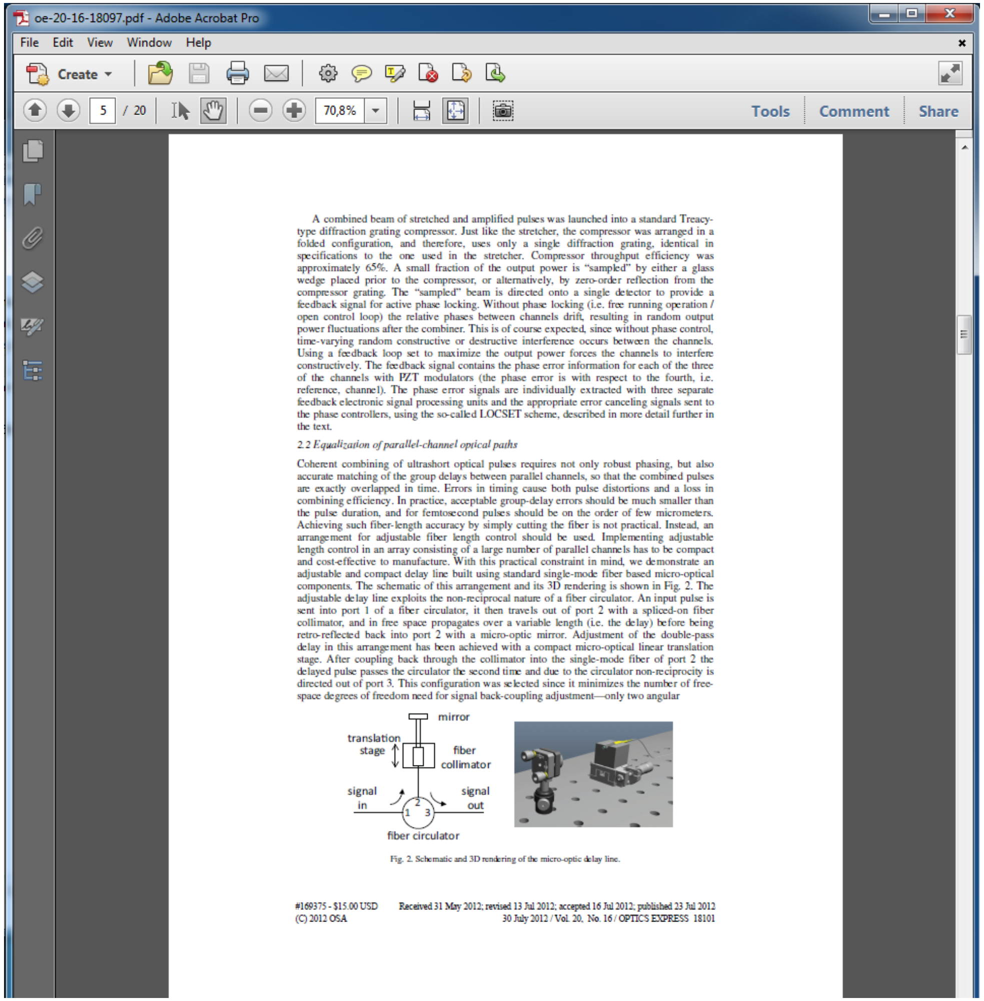
Fig. 2. Schematic and 3D rendering of the micro-optic delay line.

#169375 - $15.00 USD Received 31 May 2012; revised 13 Jul 2012; accepted 16 Jul 2012; published 23 Jul 2012
(C) 2012 OSA 30 July 2012 / Vol. 20, No. 16 / OPTICS EXPRESS 18101

Leo A. Siiman, Wei-zung Chang, Tong Zhou, and Almantas Galvanauskas. (2012). Coherent femtosecond pulse combining of multiple parallel chirped pulse fiber amplifiers. *Optics Express 20*, 18097-18116.

http://www.opticsinfobase.org/oe/abstract.cfm?URI=oe-20-16-18097

Digital publications



A combined beam of stretched and amplified pulses was launched into a standard Treacy-type diffraction grating compressor. Just like the stretcher, the compressor was arranged in a folded configuration, and therefore, uses only a single diffraction grating, identical in specifications to the one used in the stretcher. Compressor throughput efficiency was approximately 65%. A small fraction of the output power is "sampled" by either a glass wedge placed prior to the compressor, or alternatively, by zero-order reflection from the compressor grating. The "sampled" beam is directed onto a single detector to provide a feedback signal for active phase locking. Without phase locking (i.e. free running operation / open control loop) the relative phases between channels drift, resulting in random output power fluctuations after the combiner. This is of course expected, since without phase control, time-varying random constructive or destructive interference occurs between the channels. Using a feedback loop set to maximize the output power forces the channels to interfere constructively. The feedback signal contains the phase error information for each of the three of the channels with PZT modulators (the phase error is with respect to the fourth, i.e. reference, channel). The phase error signals are individually extracted with three separate feedback electronic signal processing units and the appropriate error canceling signals sent to the phase controllers, using the so-called LOCSET scheme, described in more detail further in the text.

2.2 *Equalization of parallel-channel optical paths*

Coherent combining of ultrashort optical pulses requires not only robust phasing, but also accurate matching of the group delays between parallel channels, so that the combined pulses are exactly overlapped in time. Errors in timing cause both pulse distortions and a loss in combining efficiency. In practice, acceptable group-delay errors should be much smaller than the pulse duration, and for femtosecond pulses should be on the order of few micrometers. Achieving such fiber-length accuracy by simply cutting the fiber is not practical. Instead, an arrangement for adjustable fiber length control should be used. Implementing adjustable length control in an array consisting of a large number of parallel channels has to be compact and cost-effective to manufacture. With this practical constraint in mind, we demonstrate an adjustable and compact delay line built using standard single-mode fiber based micro-optical components. The schematic of this arrangement and its 3D rendering is shown in Fig. 2. The adjustable delay line exploits the non-reciprocal nature of a fiber circulator. An input pulse is sent into port 1 of a fiber circulator, it then travels out of port 2 with a spliced-on fiber collimator, and in free space propagates over a variable length (i.e. the delay) before being retro-reflected back into port 2 with a micro-optic mirror. Adjustment of the double-pass delay in this arrangement has been achieved with a compact micro-optical linear translation stage. After coupling back through the collimator into the single-mode fiber of port 2 the delayed pulse passes the circulator the second time and due to the circulator non-reciprocity is directed out of port 3. This configuration was selected since it minimizes the number of free-space degrees of freedom need for signal back-coupling adjustment—only two angular

Fig. 2. Schematic and 3D rendering of the micro-optic delay line.

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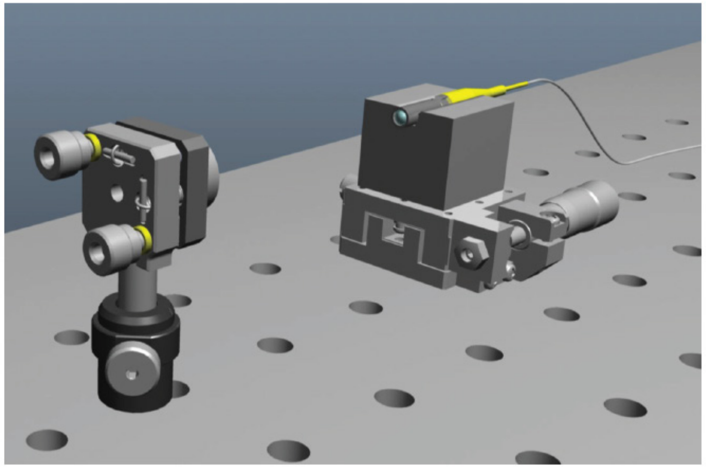


Interactive e-content

http://lingid.ee/InteractivePDF

Margus Pedaste

- Professor of technology education at the University of Tartu

Margus Pedaste

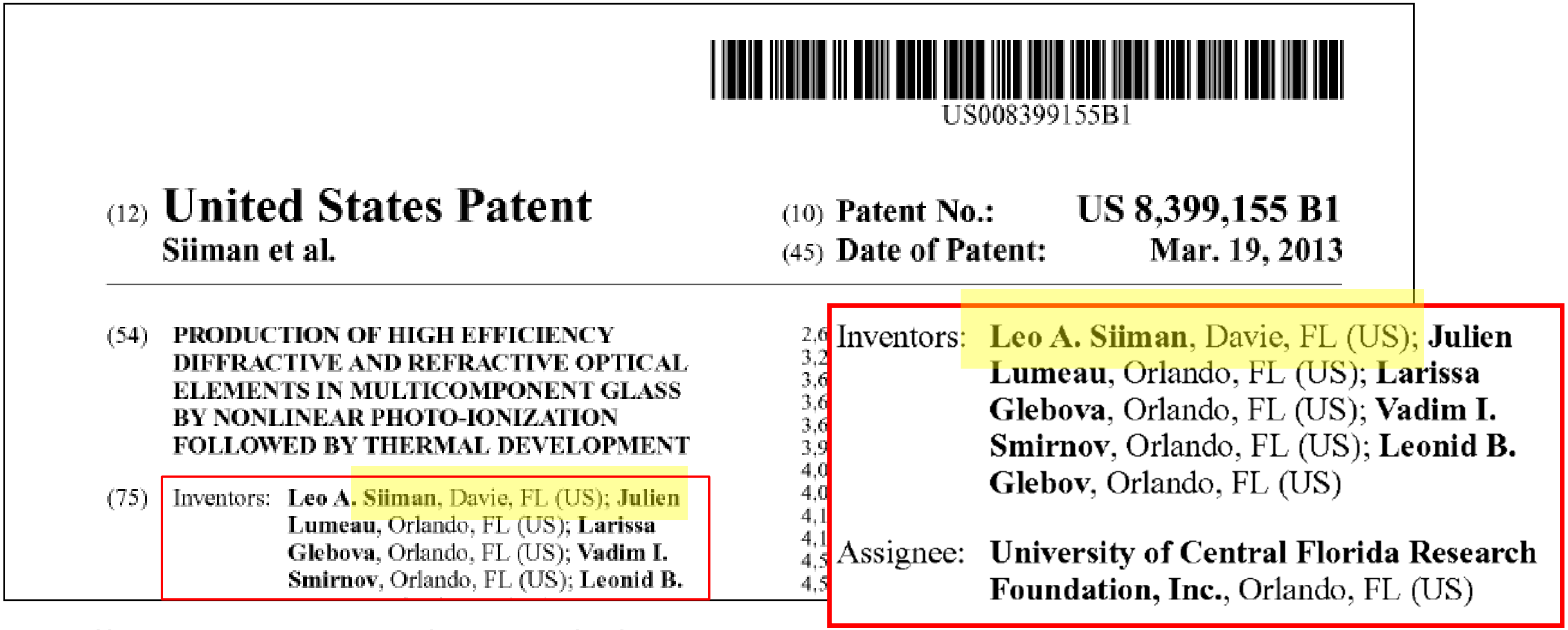
- Professor of technology education at the University of Tartu
- What research does he focus on?
  - Inquiry learning
  - Educational technology

Inquiry learning

- Learning to think like a scientist
  (not only learning what a scientist knows)

Inquiry learning

- Learning to think like a scientist (not only learning what a scientist knows)



US008399155B1

(12) **United States Patent**
Siiman et al.

(10) **Patent No.:** **US 8,399,155 B1**
(45) **Date of Patent:** **Mar. 19, 2013**

(54) **PRODUCTION OF HIGH EFFICIENCY DIFFRACTIVE AND REFRACTIVE OPTICAL ELEMENTS IN MULTICOMPONENT GLASS BY NONLINEAR PHOTO-IONIZATION FOLLOWED BY THERMAL DEVELOPMENT**

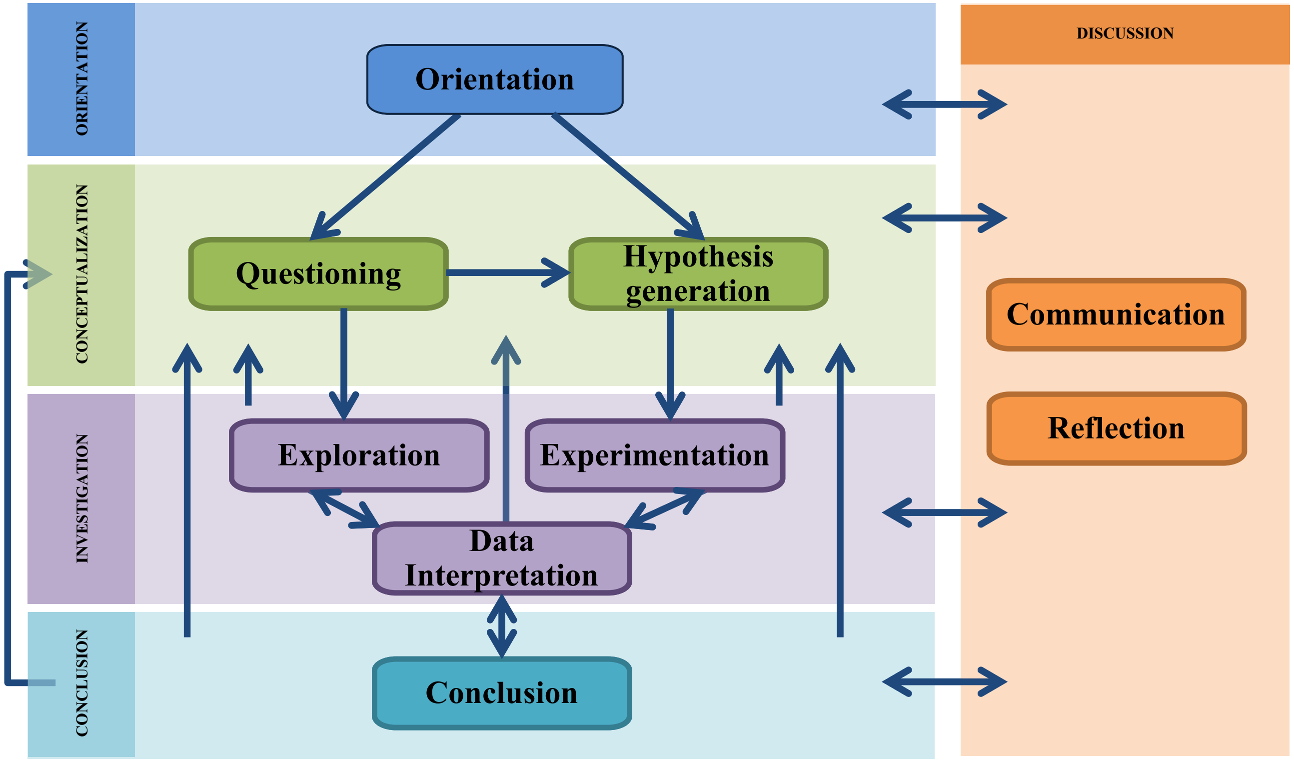
(75) Inventors: **Leo A. Siiman**, Davie, FL (US); **Julien Lumeau**, Orlando, FL (US); **Larissa Glebova**, Orlando, FL (US); **Vadim I. Smirnov**, Orlando, FL (US); **Leonid B.**

Inventors: **Leo A. Siiman**, Davie, FL (US); **Julien Lumeau**, Orlando, FL (US); **Larissa Glebova**, Orlando, FL (US); **Vadim I. Smirnov**, Orlando, FL (US); **Leonid B.** **Glebov**, Orlando, FL (US)

Assignee: **University of Central Florida Research Foundation, Inc.**, Orlando, FL (US)

http://www.google.com/patents/US8399155

Inquiry learning cycle



Margus Pedaste, Mario Mäeots, **Leo A Siiman**, Ton de Jong, Siswa A. N. van Riesen, Ellen T Kamp, Constantinos C Manoli, Zacharias C Zacharia, Eleftheria Tsourlidaki. (2015). Phases of inquiry-based learning: definitions and inquiry cycle *Under review process in the journal Educational Research Review*

Go-Lab project

- Web-based learning environment
- Opens up online science laboratories/ remote and virtual labs for the large-scale use in education
- Inquiry learning, personalized experiments

http://www.go-lab-project.eu

http://www.golabz.eu

GO-LAB

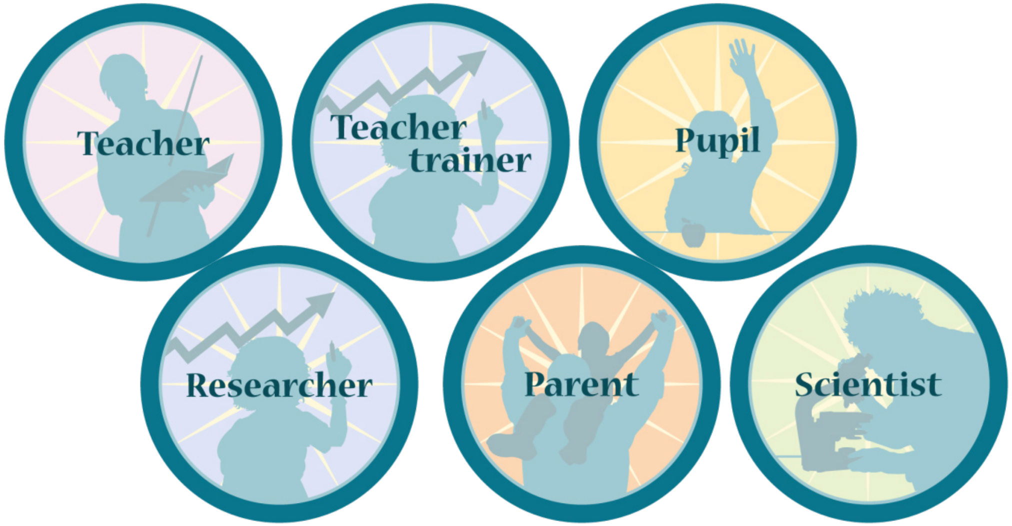
Go-Lab example

http://lingid.ee/guppy

Ark of Inquiry project

- Oriented towards raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education

http://www.arkofinquiry.eu



Ark of Inquiry

Inquiry proficiency levels

INQUIRY PHASE	Structured inquiry	Guided inquiry	Open inquiry
Orientation	Prescribed problem	Prescribed problem space	Not prescribed
Conceptualisation	Prescribed hypotheses/ research questions	Prescribed hypothesis model or structure	Not prescribed
Investigation	Prescribed experimental methodology	Not prescribed	Not prescribed
Conclusion	Not prescribed	Not prescribed	Not prescribed
Discussion	Not prescribed	Not prescribed	Not prescribed

The role of teachers

- Accustomed to assigning students prescribed problems and having them practice routine prescribed procedures
- But students are capable of defining their own problem, search for a solution and learning via this process
- The teachers role is to support student self-regulated learning and providing expert feedback

We should give students fishing poles, not the fish!

New 3D technology comes to school

3D-printers in Estonian schools

February 6, 2014

Õpetajate Leht

ÜLDHARIDUS

3D-printer on koolitunnis saanud reaalsuseks

6. veebruar 2014 Sirje Pärismaa - Kommenteeri artiklit

Tartu Tamme gümnaasiumi õpetaja Tiiu Laan näitab akadeemik Ene Ergmale õpilaste katsetusi 3D-printeriga. Tagaplaanil „imeseade" ise.

Tartu Tamme gümnaasium on esimese Eesti koolina võtnud tehnoloogia õppesuuna tundides kasutusele 3D-printeri. 4. veebruaril toimunud tehnoloogia minimessil said seda seadet ja muid insenerimõtte loovaid lahendusi katsetada ka teiste suundade õppurid ning saali pistis nina algklassilapsigi.

Tavatundide asemel toimusid robootika, mudellennunduse, digiandmekogujate kasutamise loodusteaduslike katsete töötoad. Tegutsesid leiutajad, proovida sai veebipõhist vastamissüsteemi, QR-koodi rakendamist õppetöös, arvutiga juhitavat tikkimismasinat.

Direktor Vallo Reimaa sõnul on kool ostnud tehnoloogiasuuna õppetööks vajalikku nüüdisaegset aparatuuri teenitud omavahenditest, et muuta õppimine intrigeerivaks.

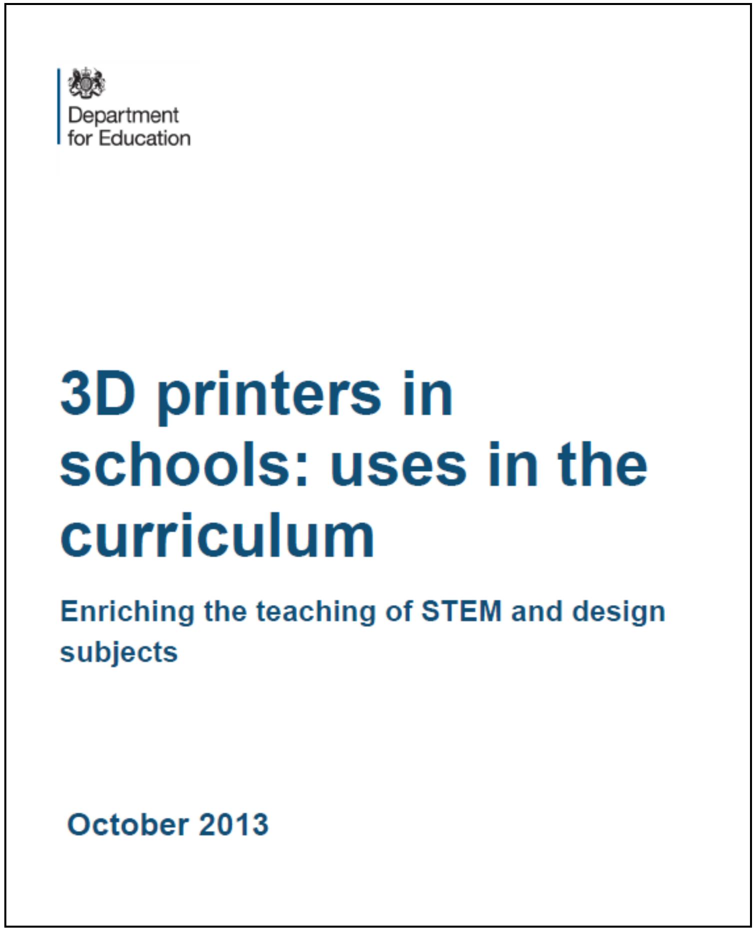
http://opleht.ee/13236-3d-printer-on-koolitunnis-saanud-reaalsuseks/

What is 3D-printing?

http://lingid.ee/3Dprinting

United Kingdom study

October 2013



Department for Education

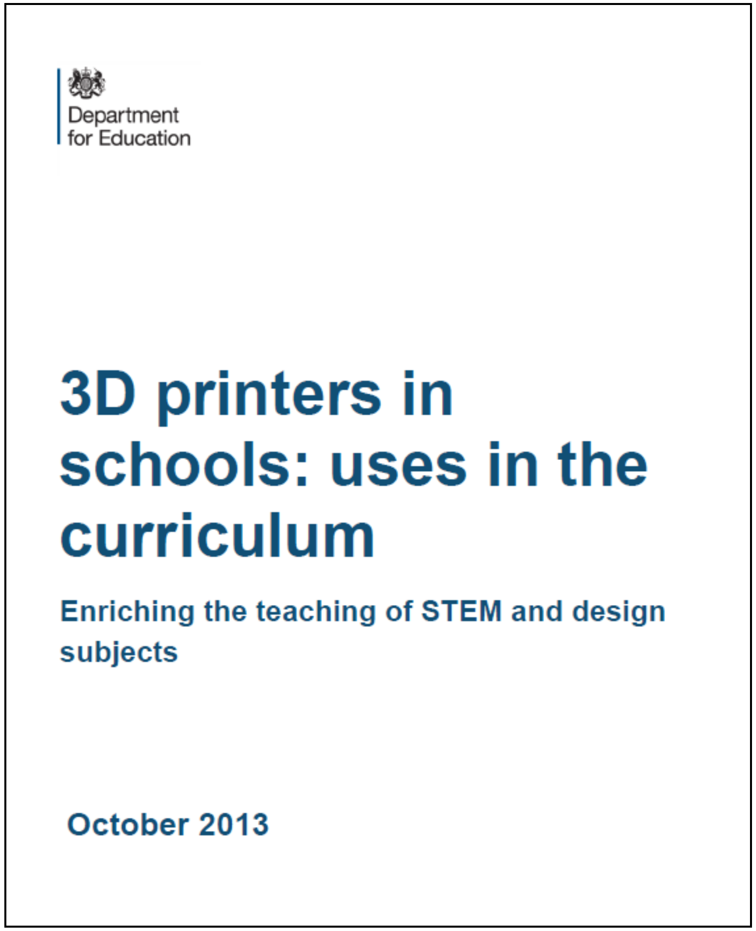
3D printers in schools: uses in the curriculum

Enriching the teaching of STEM and design subjects

October 2013

United Kingdom study

October 2013



Department for Education

3D printers in schools: uses in the curriculum

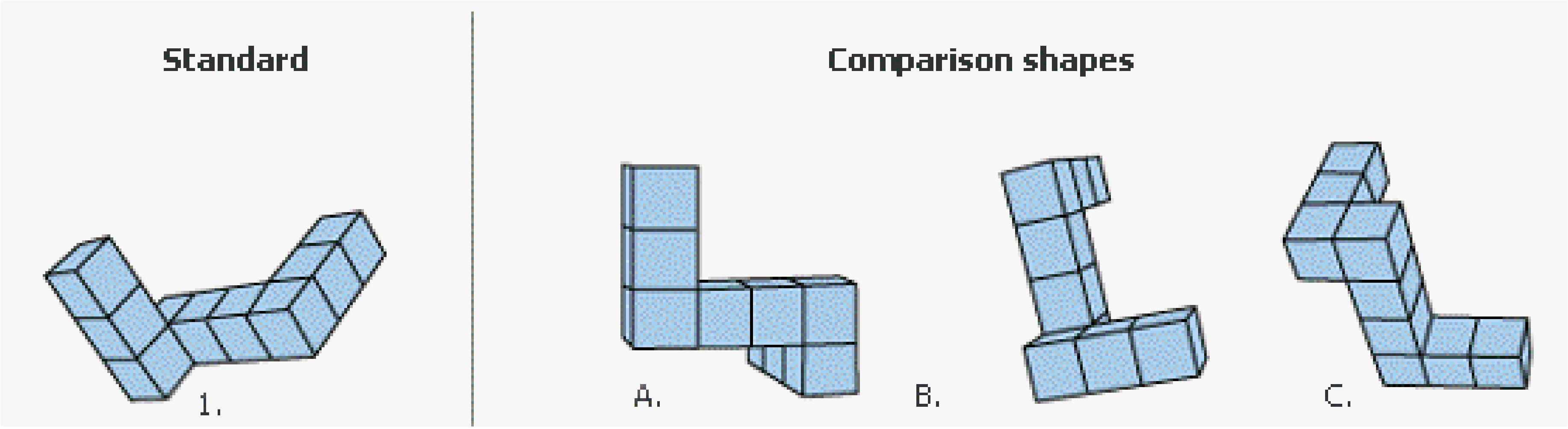
Enriching the teaching of STEM and design subjects

October 2013

"… 3D printers have significant potential as a teaching resource and can have a positive impact on pupil engagement and learning if schools can master how to use the printers in an effective and meaningful way."

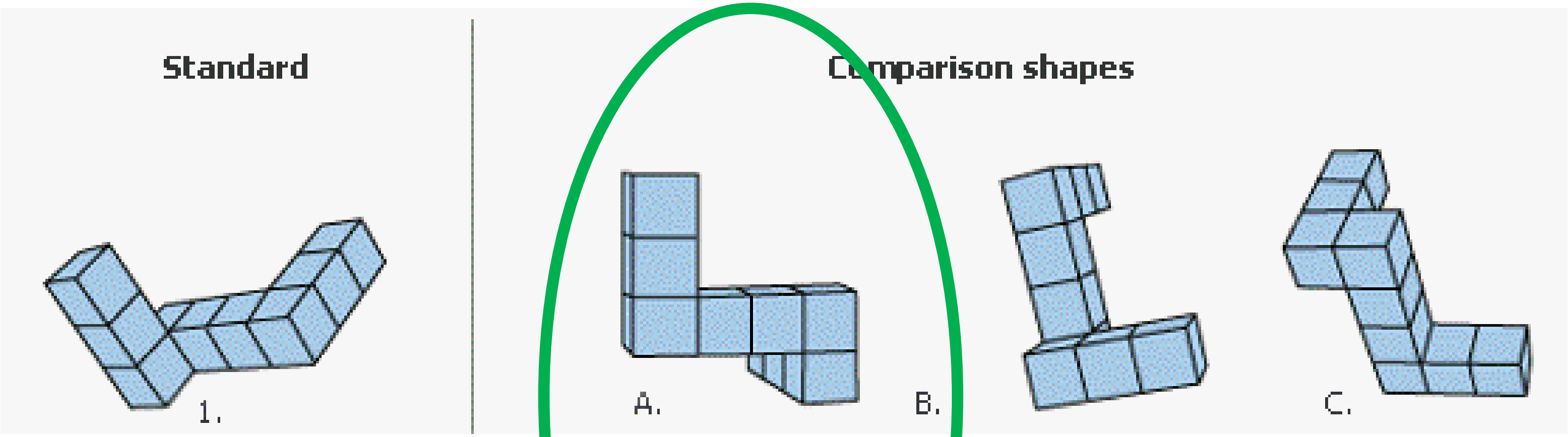
Why can 3D technology improve education?

Spatial ability



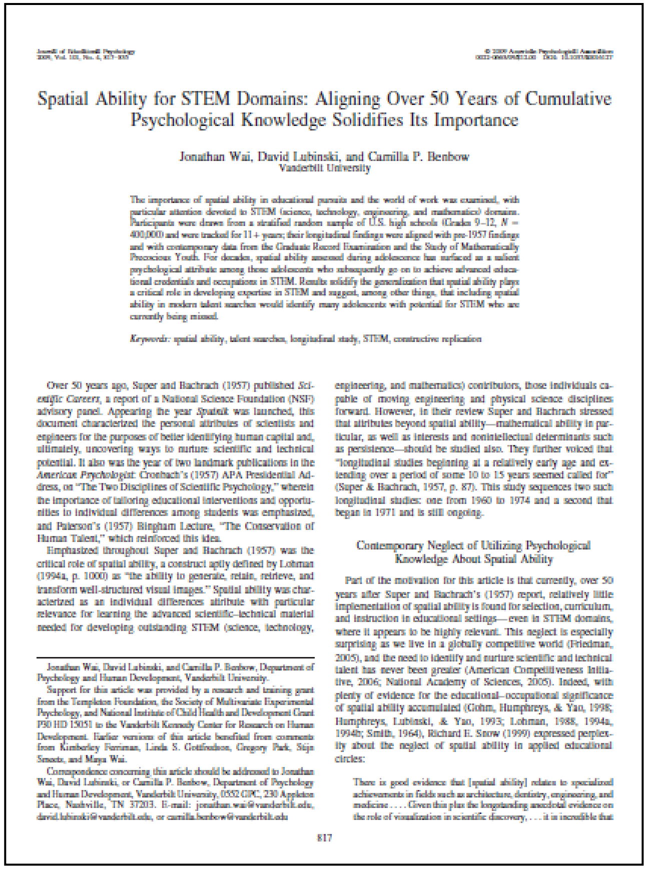
A B C

Spatial ability



A B C

Importance of spatial ability



Spatial Ability for STEM Domains: Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies Its Importance

Jonathan Wai, David Lubinski, and Camilla P. Benbow
Vanderbilt University

The importance of spatial ability in educational pursuits and the world of work was examined, with particular attention devoted to STEM (science, technology, engineering, and mathematics) domains. Participants were drawn from a stratified random sample of U.S. high schools (Grades 9–12, N = 400,000) and were tracked for 11+ years; their longitudinal findings were aligned with pre-1957 findings and with contemporary data from the Graduate Record Examination and the Study of Mathematically Precocious Youth. For decades, spatial ability assessed during adolescence has surfaced as a salient psychological attribute among those adolescents who subsequently go on to achieve advanced educational credentials and occupations in STEM. Results solidify the generalization that spatial ability plays a critical role in developing expertise in STEM and suggest, among other things, that including spatial ability in modern talent searches would identify many adolescents with potential for STEM who are currently being missed.

Keywords: spatial ability, talent searches, longitudinal study, STEM, constructive replication

Over 50 years ago, Super and Bachrach (1957) published *Scientific Careers*, a report of a National Science Foundation (NSF) advisory panel. Appearing the year *Sputnik* was launched, this document characterized the personal attributes of scientists and engineers for the purposes of better identifying human capital and, ultimately, uncovering ways to nurture scientific and technical potential. It also was the year of two landmark publications in the *American Psychologist*: Cronbach's (1957) APA Presidential Address, on "The Two Disciplines of Scientific Psychology," wherein the importance of tailoring educational interventions and opportunities to individual differences among students was emphasized, and Paterson's (1957) Bingham Lecture, "The Conservation of Human Talent," which reinforced this idea.

Emphasized throughout Super and Bachrach (1957) was the critical role of spatial ability, a construct aptly defined by Lohman (1994a, p. 1000) as "the ability to generate, retain, retrieve, and transform well-structured visual images." Spatial ability was characterized as an individual differences attribute with particular relevance for learning the advanced scientific–technical material needed for developing outstanding STEM (science, technology, engineering, and mathematics) contributors, those individuals capable of moving engineering and physical science disciplines forward. However, in their review Super and Bachrach stressed that attributes beyond spatial ability—mathematical ability in particular, as well as interests and nonintellectual determinants such as persistence—should be studied also. They further voiced that "longitudinal studies beginning at a relatively early age and extending over a period of some 10 to 15 years seemed called for" (Super & Bachrach, 1957, p. 87). This study sequences two such longitudinal studies: one from 1960 to 1974 and a second that began in 1971 and is still ongoing.

Contemporary Neglect of Utilizing Psychological Knowledge About Spatial Ability

Part of the motivation for this article is that currently, over 50 years after Super and Bachrach's (1957) report, relatively little implementation of spatial ability is found for selection, curriculum, and instruction in educational settings—even in STEM domains, where it appears to be highly relevant. This neglect is especially surprising as we live in a globally competitive world (Friedman, 2005), and the need to identify and nurture scientific and technical talent has never been greater (American Competitiveness Initiative, 2006; National Academy of Sciences, 2005). Indeed, with plenty of evidence for the educational–occupational significance of spatial ability accumulated (Gohm, Humphreys, & Yao, 1998; Humphreys, Lubinski, & Yao, 1993; Lohman, 1988, 1994a, 1994b; Smith, 1964), Richard E. Snow (1999) expressed perplexity about the neglect of spatial ability in applied educational circles:

> There is good evidence that [spatial ability] relates to specialized achievements in fields such as architecture, dentistry, engineering, and medicine . . . . Given this plus the longstanding anecdotal evidence on the role of visualization in scientific discovery, . . . it is incredible that

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Jonathan Wai, David Lubinski, and Camilla P. Benbow, Department of Psychology and Human Development, Vanderbilt University.

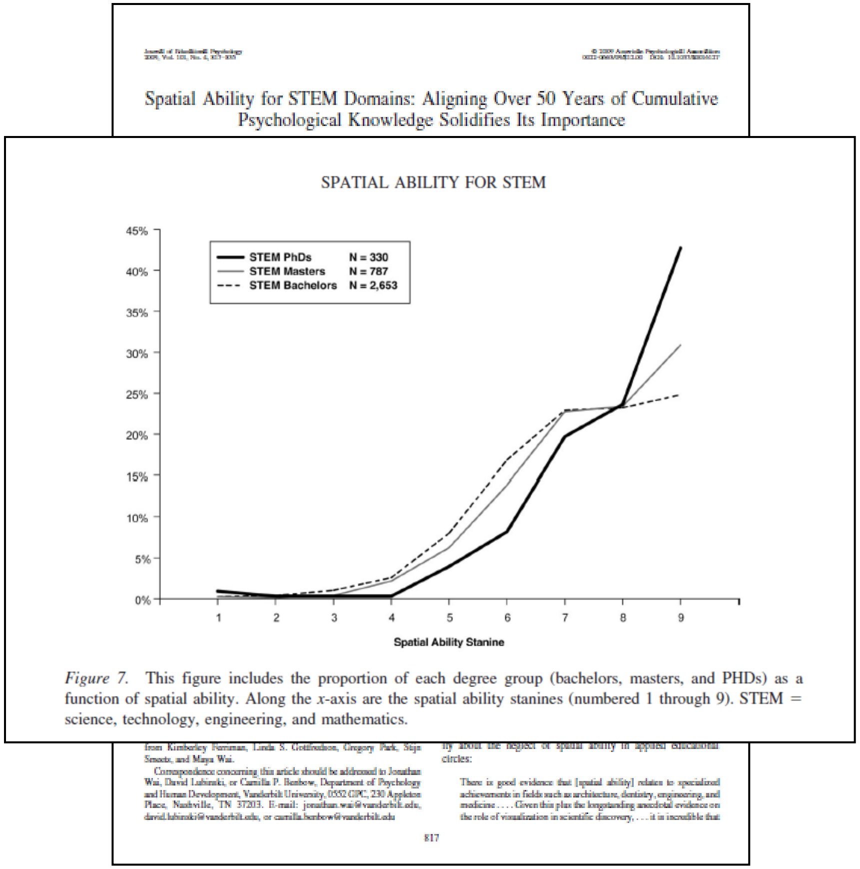
Support for this article was provided by a research and training grant from the Templeton Foundation, the Society of Multivariate Experimental Psychology, and National Institute of Child Health and Development Grant P30 HD 15051 to the Vanderbilt Kennedy Center for Research on Human Development. Earlier versions of this article benefited from comments from Kimberley Ferriman, Linda S. Gottfredson, Gregory Park, Stijn Smeets, and Maya Wai.

Correspondence concerning this article should be addressed to Jonathan Wai, David Lubinski, or Camilla P. Benbow, Department of Psychology and Human Development, Vanderbilt University, 0552 GPC, 230 Appleton Place, Nashville, TN 37203. E-mail: jonathan.wai@vanderbilt.edu, david.lubinski@vanderbilt.edu, or camilla.benbow@vanderbilt.edu

- 11-year longitudinal study
- High school students in the US (N=400,000)

Wai, J., Lubinski, D., & Benbow C. P. (2009). Spatial Ability for STEM Domains: Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies Its Importance. Journal of Educational Psychology, 101, 817-835.

Importance of spatial ability



Spatial Ability for STEM Domains: Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies Its Importance

SPATIAL ABILITY FOR STEM

Figure 7. This figure includes the proportion of each degree group (bachelors, masters, and PHDs) as a function of spatial ability. Along the *x*-axis are the spatial ability stanines (numbered 1 through 9). STEM = science, technology, engineering, and mathematics.

from Kimberley Ferriman, Linda S. Gottfredson, Gregory Park, Stijn Smeets, and Maya Wai.

Correspondence concerning this article should be addressed to Jonathan Wai, David Lubinski, or Camilla P. Benbow, Department of Psychology and Human Development, Vanderbilt University, 0552 GPC, 230 Appleton Place, Nashville, TN 37203. E-mail: jonathan.wai@vanderbilt.edu, david.lubinski@vanderbilt.edu, or camilla.benbow@vanderbilt.edu

ity about the neglect of spatial ability in applied educational circles:

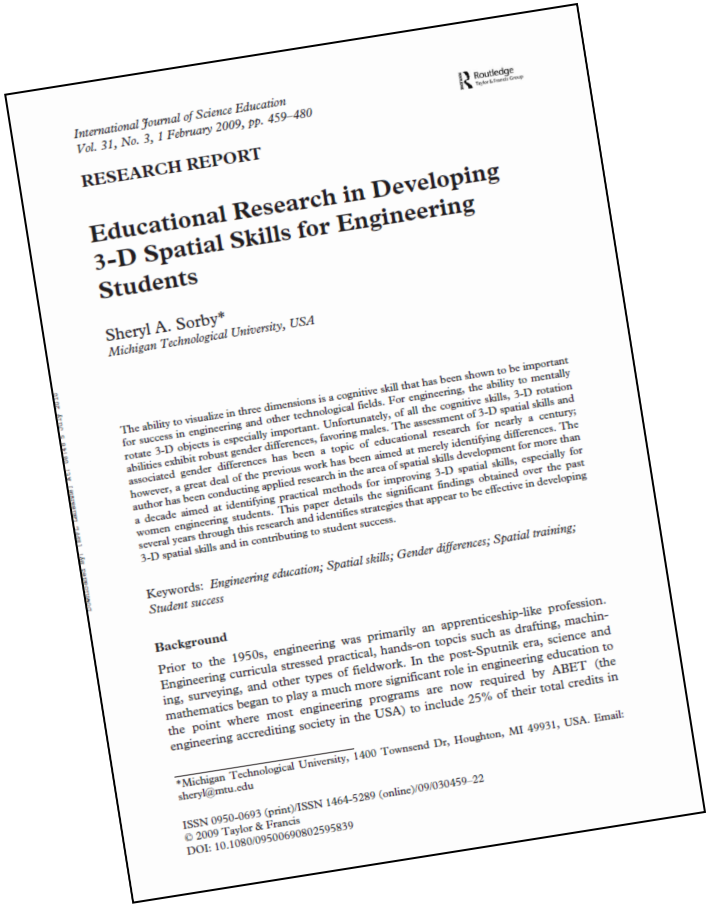
> There is good evidence that [spatial ability] relates to specialized achievements in fields such as architecture, dentistry, engineering, and medicine . . . . Given this plus the longstanding anecdotal evidence on the role of visualization in scientific discovery, . . . it is incredible that

817

The best researchers in science, technology, engineering and mathematics (STEM) have a high level of spatial ability

Wai, J., Lubinski, D., & Benbow C. P. (2009). Spatial Ability for STEM Domains: Aligning Over 50 Years of Cumulative Psychological Knowledge Solidifies Its Importance. Journal of Educational Psychology, 101, 817-835.

Developing spatial skills



International Journal of Science Education
Vol. 31, No. 3, 1 February 2009, pp. 459–480

Routledge

RESEARCH REPORT

Educational Research in Developing 3-D Spatial Skills for Engineering Students

Sheryl A. Sorby*
Michigan Technological University, USA

The ability to visualize in three dimensions is a cognitive skill that has been shown to be important for success in engineering and other technological fields. For engineering, the ability to mentally rotate 3-D objects is especially important. Unfortunately, of all the cognitive skills, 3-D rotation abilities exhibit robust gender differences, favoring males. The assessment of 3-D spatial skills and associated gender differences has been a topic of educational research for nearly a century; however, a great deal of the previous work has been aimed at merely identifying differences. The author has been conducting applied research in the area of spatial skills development for more than a decade aimed at identifying practical methods for improving 3-D spatial skills, especially for women engineering students. This paper details the significant findings obtained over the past several years through this research and identifies strategies that appear to be effective in developing 3-D spatial skills and in contributing to student success.

Keywords: *Engineering education; Spatial skills; Gender differences; Spatial training; Student success*

Background

Prior to the 1950s, engineering was primarily an apprenticeship-like profession. Engineering curricula stressed practical, hands-on topcis such as drafting, machining, surveying, and other types of fieldwork. In the post-Sputnik era, science and mathematics began to play a much more significant role in engineering education to the point where most engineering programs are now required by ABET (the engineering accrediting society in the USA) to include 25% of their total credits in

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*Michigan Technological University, 1400 Townsend Dr, Houghton, MI 49931, USA. Email: sheryl@mtu.edu

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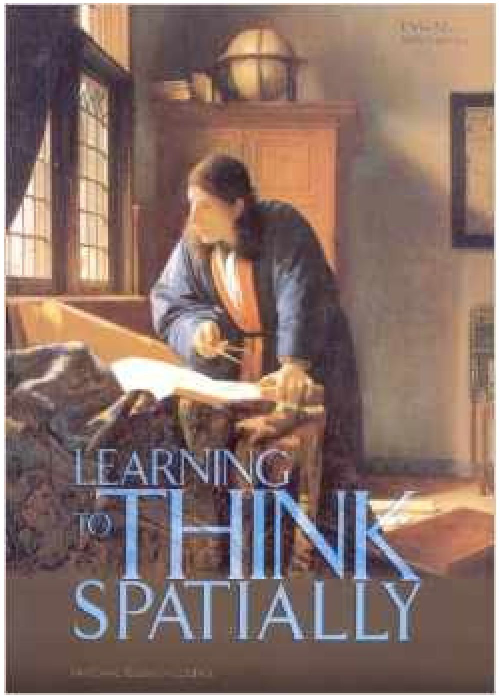
DOI: 10.1080/09500690802595839

- Spatial ability can be improved through practice
- Improved spatial ability helps female students persists in engineering studies

Sorby, S. A. (2009). Educational research in developing 3-D spatial skills for engineering students. *International Journal of Science Education, 31*(3), 459-480.

Research problem



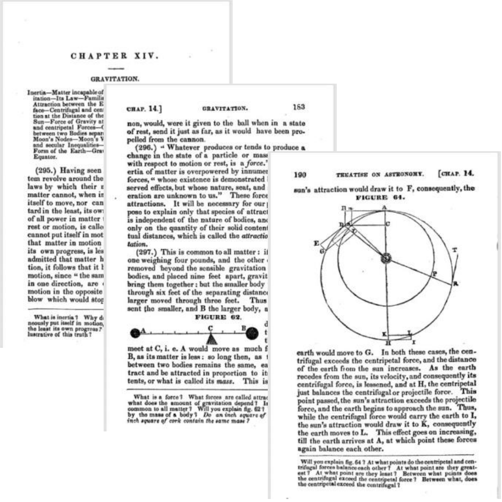
Spatial thinking is the start of successful thinking and problem solving. Skill in spatial thinking is presumed throughout the K–12 curriculum but is formally and systematically taught nowhere. This leads to an ***educational blind spot****.*

(National Research Council, 2006, p. 131)

National Research Council (2006). Learning to Think Spatially—GIS as a Support System in the K-12 Curriculum. Washington DC: The National Academies Press.

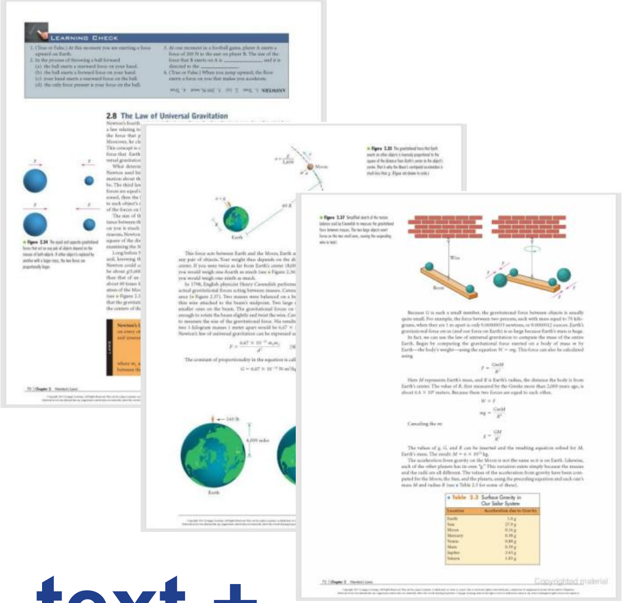
Visualization in learning

L.H. Tyler, A Treatiste on Astronomy (1837)



mostly text

V.J. Ostdiek, D.J. Bord, Inquiry into Physics (2011)



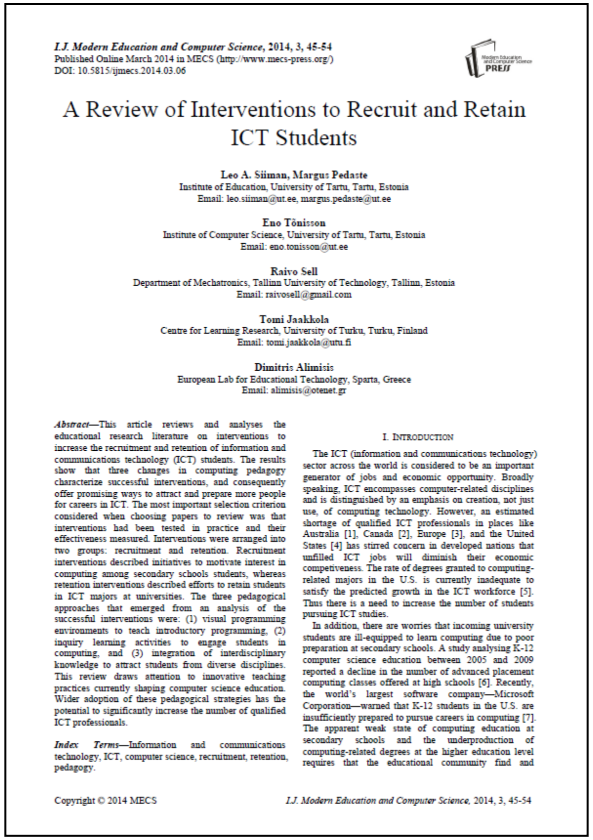
text + ample use of pictures

Next-generation learning content

???

???

ICT student dropout



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Published Online March 2014 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijmecs.2014.03.06

A Review of Interventions to Recruit and Retain ICT Students

Leo A. Siiman, Margus Pedaste
Institute of Education, University of Tartu, Tartu, Estonia
Email: leo.siiman@ut.ee, margus.pedaste@ut.ee

Eno Tõnisson
Institute of Computer Science, University of Tartu, Tartu, Estonia
Email: eno.tonisson@ut.ee

Raivo Sell
Department of Mechatronics, Tallinn University of Technology, Tallinn, Estonia
Email: raivosell@gmail.com

Tomi Jaakkola
Centre for Learning Research, University of Turku, Turku, Finland
Email: tomi.jaakkola@utu.fi

Dimitris Alimisis
European Lab for Educational Technology, Sparta, Greece
Email: alimisis@otenet.gr

***Abstract*—This article reviews and analyses the educational research literature on interventions to increase the recruitment and retention of information and communications technology (ICT) students. The results show that three changes in computing pedagogy characterize successful interventions, and consequently offer promising ways to attract and prepare more people for careers in ICT. The most important selection criterion considered when choosing papers to review was that interventions had been tested in practice and their effectiveness measured. Interventions were arranged into two groups: recruitment and retention. Recruitment interventions described initiatives to motivate interest in computing among secondary schools students, whereas retention interventions described efforts to retain students in ICT majors at universities. The three pedagogical approaches that emerged from an analysis of the successful interventions were: (1) visual programming environments to teach introductory programming, (2) inquiry learning activities to engage students in computing, and (3) integration of interdisciplinary knowledge to attract students from diverse disciplines. This review draws attention to innovative teaching practices currently shaping computer science education. Wider adoption of these pedagogical strategies has the potential to significantly increase the number of qualified ICT professionals.

***Index Terms*—Information and communications technology, ICT, computer science, recruitment, retention, pedagogy.

I. INTRODUCTION

The ICT (information and communications technology) sector across the world is considered to be an important generator of jobs and economic opportunity. Broadly speaking, ICT encompasses computer-related disciplines and is distinguished by an emphasis on creation, not just use, of computing technology. However, an estimated shortage of qualified ICT professionals in places like Australia [1], Canada [2], Europe [3], and the United States [4] has stirred concern in developed nations that unfilled ICT jobs will diminish their economic competiveness. The rate of degrees granted to computing-related majors in the U.S. is currently inadequate to satisfy the predicted growth in the ICT workforce [5]. Thus there is a need to increase the number of students pursuing ICT studies.

In addition, there are worries that incoming university students are ill-equipped to learn computing due to poor preparation at secondary schools. A study analysing K-12 computer science education between 2005 and 2009 reported a decline in the number of advanced placement computing classes offered at high schools [6]. Recently, the world's largest software company—Microsoft Corporation—warned that K-12 students in the U.S. are insufficiently prepared to pursue careers in computing [7]. The apparent weak state of computing education at secondary schools and the underproduction of computing-related degrees at the higher education level requires that the educational community find and

What have been effective interventions to prevent ICT university student dropout?

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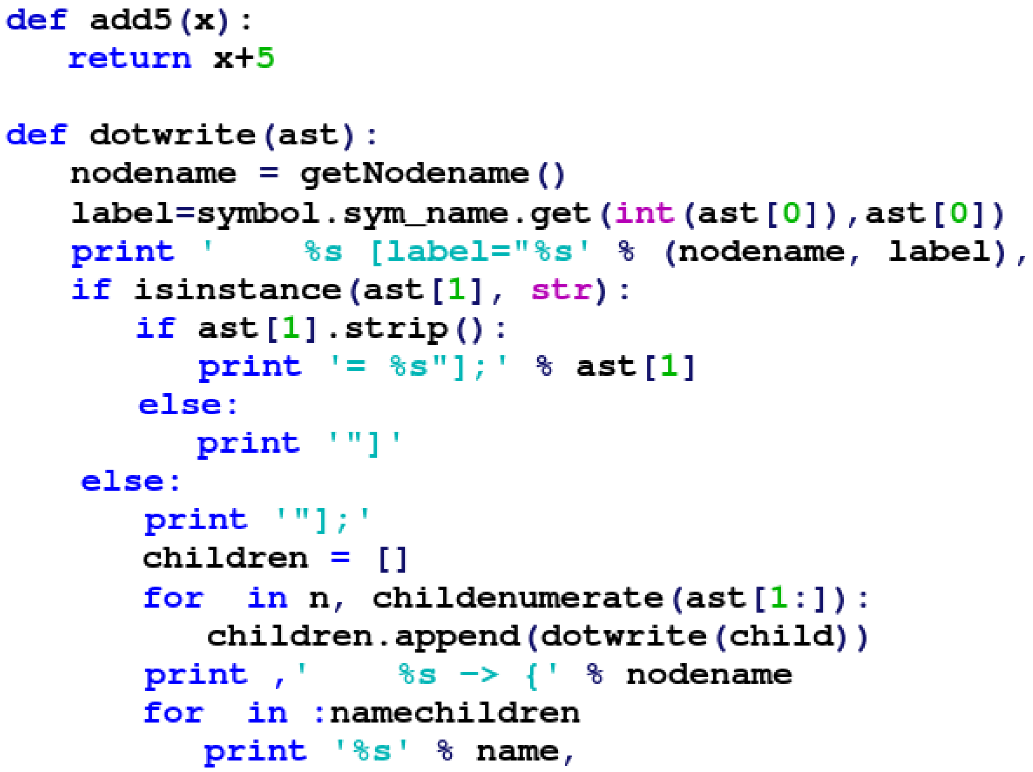
Computer programming is difficult when introduced first in text-only format



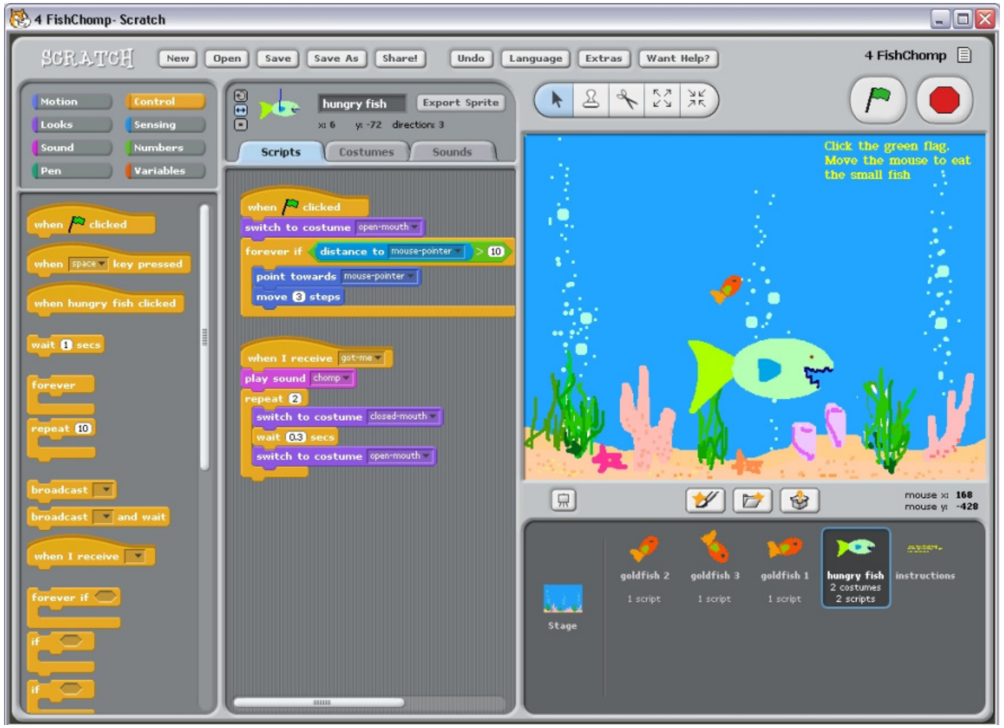
```
def add5(x):
    return x+5

def dotwrite(ast):
    nodename = getNodename()
    label=symbol.sym_name.get(int(ast[0]),ast[0])
    print '    %s [label="%s' % (nodename, label),
    if isinstance(ast[1], str):
        if ast[1].strip():
            print '= %s"];' % ast[1]
        else:
            print '"]'
    else:
        print '"];'
        children = []
        for  in n, childenumerate(ast[1:]):
            children.append(dotwrite(child))
        print ,'    %s -> {' % nodename
        for  in :namechildren
            print '%s' % name,
```

http://commons.wikimedia.org/wiki/Category:Python_(programming_language)#mediaviewer/File:Python_add5_syntax.svg

Visual programming languages

Scratch



```
when [flag] clicked
switch to costume open-mouth
forever if distance to mouse-pointer > 10
  point towards mouse-pointer
  move 3 steps

when I receive got-me
play sound chomp
repeat 2
  switch to costume closed-mouth
  wait 0.3 secs
  switch to costume open-mouth
```

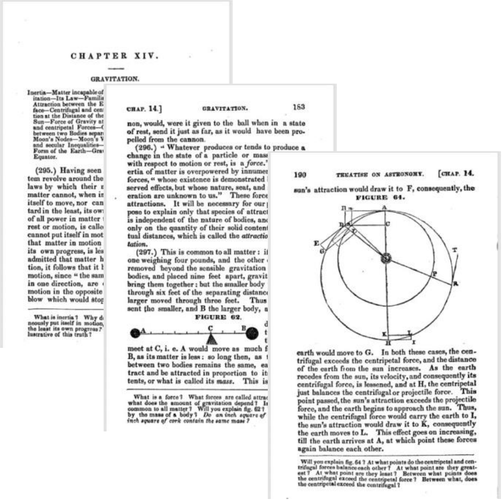
Alice 3D

```
declare procedure run on class MyScene
do in order
```

http://www.cs.duke.edu/csed/alice/aliceInSchools/workshop11/alice3/CodeXEditor.png
http://www.engagingeducators.com/blog/wp-content/uploads/2013/10/scratch-01.jpg

Visualization in learning

L.H. Tyler, A Treatiste on Astronomy (1837)



190 TREATISE ON ASTRONOMY. [CHAP. 14.

sun's attraction would draw it to F, consequently, the

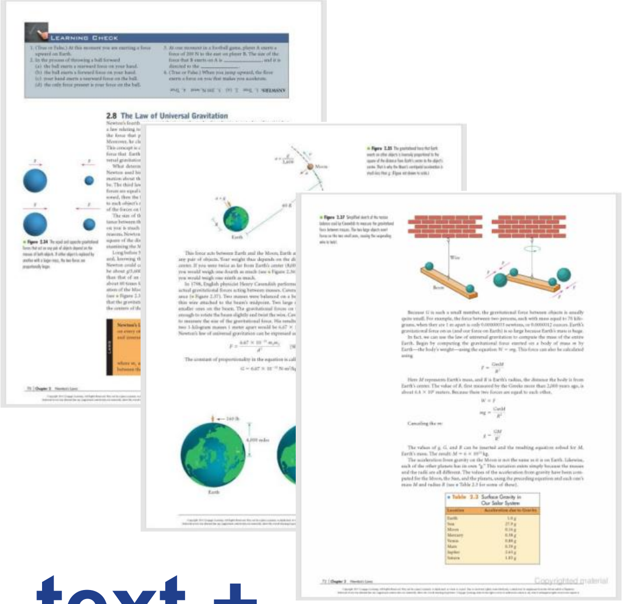
FIGURE 64.

earth would move to G. In both these cases, the centrifugal exceeds the centripetal force, and the distance of the earth from the sun increases. As the earth recedes from the sun, its velocity, and consequently its centrifugal force, is lessened, and at H, the centripetal just balances the centrifugal or projectile force. This point passed, the sun's attraction exceeds the projectile force, and the earth begins to approach the sun. Thus, while the centrifugal force would carry the earth to I, the sun's attraction would draw it to K, consequently the earth moves to L. This effect goes on increasing, till the earth arrives at A, at which point these forces again balance each other.

Will you explain fig. 64? At what points do the centripetal and centrifugal forces balance each other? At what point are they greatest? At what point are they least? Between what points does the centrifugal exceed the centripetal force? Between what, does the centripetal exceed the centrifugal?

mostly text

V.J. Ostdiek, D.J. Bord, Inquiry into Physics (2011)



text + ample use of pictures

Next-generation learning content

???

???

Smithsonian Institute models

http://3d.si.edu

Biodigi project

- Creating new digital learning materials for upper secondary school biology course
- Variety of formats: electronic worksheets, digital audio files, digital videos, Scratch-based programming models and online interactive 3D models

http://biodigi.edu.ee

Blender – 3D freeware

http://www.blender.org

Roboxtex 2014 workshop

- Workshop to use a 3D-scanner and later work with the digital 3D-model in Blender
- 22 participants (aged 7 to 58)
- Questionnaire data collected and being processed

What else does a 3D future promise?

Eric Platt. (2012). A Bunch Of Models Rocked Google Glasses At New York Fashion Week. *Business Insider,* September 10, 2012. Photo: Frazer Harrison/Getty Images

http://www.businessinsider.com/google-glasses-diane-von-furstenberg-2012-9?op=1

Estonian 3D company GrabCAD

Eesti start-up GrabCAD müüdi väidetavalt 100 miljoni dollari eest

16.09.2014 16:47

Rubriik: Majandus

Nasdaqi börsil noteeritud 3D printerite ja printimislahenduste tootja Stratasys ostis väidetavalt 100 miljoni dollari (ligi 77 miljonit

16. september 2014

Largest Estonian startup acquisition since Skype

Conclusion

- It is important to make careers in the STEM fields attractive and prepare students with scientific **inquiry thinking skills**
- New 3D technologies are promising tools to help develop fundamental abilities (e.g. visualization skills, spatial ability) students need to succeed in STEM subjects
- **Education research** is needed to examine the effectiveness of teaching and learning with new 3D technologies

Estonian National Curriculum

- Inquiry learning

  Secondary school students are required to complete an research or practical project work

  To help better direct student research work teachers need to understanding scientific inquiry

- Digital competence (general competence)

  Digital competence means readiness to use digital technology to cope in a rapidly changing knowledge-based society when working, studying, acting and communicating as a citizen.

Research problems

- What STEM concepts and practices are learnt better through 3D learning activities than by traditional approaches?
- How to measure and assess the outcomes of 3D learning experiences?
- How does 3D learning affect student long-term attitudes towards STEM and their likelihood of choosing a STEM career?

The Centre for Educational Technology at the University of Tartu

- Expertise in designing and developing materials and methods to improve digital and technological literacy
- Professional pre-service and in-service courses for teachers, school-leaders, university lecturers
- Advancing education research in Estonia, in Europe and around the world

Director: Margus Pedaste

Team members: 13

http://haridustehnoloogia.ut.ee

Thank you for your attention!

Tänan kuulamast!

Leo Siiman
leo.aleksander.siiman@ut.ee
leo.siiman@ut.ee
leo@ut.ee

http://haridustehnoloogia.ut.ee