



PAL

**STEM
FLUENCY**

PAL AND ITS WORK

PAL Labs are a catalyst for innovative thinking across disciplines, sectors and borders. They result in new ideas and work which is ready to be developed and tested.

Since 1989 PAL has delivered over 144 experimental Labs with 4,100 exceptionally talented artists, scientists, educationalists, cultural policymakers and people from the creative industries.

Time and again participants push the limits of their practice and challenge the wider context in which they work. Collaborations in PAL Labs have stimulated rich and unexpected work, producing tangible results through a cost-effective R&D process.

PAL has been producing Labs in science, creative science teaching and science, technology, engineering and maths (STEM) since 1997.

We undertake bespoke commissioned work for clients ranging from individual artists and companies to national and international agencies and research councils.

PAL was founded initially to develop original work with talented writers in theatre, opera, film and music theatre. Experiments in these early years developed a highly effective methodology that has made a substantial positive impact on individuals' practice. Participants in today's PAL Labs continue to experience the coming together of artistic ways of thinking with science, academia and education.

Details of all PAL Labs to date, and people who have participated, can be found on our website www.pallabs.org/portfolio/timeline

Based in London, PAL is a registered charity and a company limited by guarantee.

THE STEM CHALLENGE

We are inundated with information telling us that young people are reluctant to commit themselves to careers in science, technology, engineering and maths (STEM) even though governments provide incentives to encourage study to higher levels.

We also know how important this value-added sector is to the global economy as it recovers from the recession, through building a high level creative industries, science, technology and manufacturing skills base.

In the UK, the Royal Society's report *The Scientific Century: securing our future prosperity (2010)*, exhorts us to place science and innovation at the heart of the UK's long-term strategy for economic growth. The report prioritises investment in excellent people, strengthening science within government, reinforcing the UK's position as a hub for global science and innovation, better aligning science and innovation with global challenges and revitalising science and mathematics education.

There are many initiatives that aim to excite young people so that they come to love STEM as much as they love the arts, humanities and sports. But we know that the crucial factor in turning them on to STEM is inspiring teaching and learning. So our collective challenge is to make sure teachers are knowledgeable, continuously learning and have the confidence and backing to innovate and try new approaches with their pupils and students. The last of these is most urgent and it is a global challenge.

Our solution is the PAL STEM Fluency Lab.

We invite everyone who is asking questions about whether current teaching and learning practice has the capability to meet the challenge to contact us and start a conversation about how PAL Labs can help you find answers.

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“When policymakers today talk about education and reform, it’s all about the STEM subjects. It’s about convergent thinking – problem solving by breaking it down. Instead, a divergent thinker takes an idea and looks to expand it, and to find new diverse ways to connect it... You need both to create balance: combining STEM with the arts to get STEAM.”

**John Maeda,
President,
Rhode Island
School of Design**

PAL LABS IN LEARNING

We are driven by two certainties:

- Collaboration, creativity, finding interdisciplinary solutions, problem solving and project management are all essential if young people are to succeed in an unknown and global labour market which is in a constant state of flux. And we all depend on them to make a better, more sustainable world.
- Inspired and creative teachers and lecturers with the practical know-how to work together across disciplines will introduce the learning habits of a lifetime to their pupils.

PAL Labs stimulate genuine collaboration across disciplines, subjects, key phases, grades and sectors. This experience proves to be a powerful intervention in teachers' lives, and in the lives of the artists, designers and scientists who work with them. Those who participate in Labs are changed, they tell us, and the resulting improvement in young people's learning is marked.

This is not just box ticking or searching for similarities in prescribed curriculum outcomes. This is about openness, imagination, inspiration and discovery.

All PAL Labs are researched and designed to address particular contexts and needs for solutions. Often they start with a conversation. It can be as simple as that.

We propose that more people experience Labs so that we can escalate brilliant teaching and learning, not only in STEM but right across the curriculum, however that is described. We have ambitions to advance PAL Labs in Learning through, for example, European Union education programmes and we will build on PAL's networks and experience around the world to share the Lab methodology wherever it might be a solution to a challenge in learning.

"My visit to the Lab on STEM Fluency showed me the value of giving time to teachers and other educators creatively to think of new ways of teaching. I would welcome any way in which such opportunities would be available to more people."

**Professor Michael Reiss,
Professor of Science Education,
Institute of Education, London**

WHAT IS A PAL STEM FLUENCY LAB?

PAL STEM Fluency Labs begin with a question, usually posed by an organisation and often expressed as a gap or challenge. Together, we open up and refine the question. To make the Lab, PAL draws in people from different disciplines and practices who each bring their own method of enquiry.

PAL Labs are an immersive, creative environment. The connection with laboratories, a place for scientific exploration and serendipity, is not accidental. All PAL Labs have rigorous enquiry at their heart.

Our most productive STEM Fluency Lab model is a five-day residential followed by a review day six months later, with around 25 participants. However, much can be done in a shorter timeframe. And a three-year PAL Lab programme leaves behind it a local centre of expertise which is independent and capable of establishing its own practice, in its own context.

PAL selects the Lab Director, interdisciplinary artists, scientists and teachers. In preparation they are all asked "What is it you want to do that you're not doing now?"

Approaching the arts and STEM together is central to the design of these PAL Labs. Professional artists and scientists are crucial to the process. As well as bringing specific knowledge and skills, they also expose teachers to new attitudes and thinking. As one teacher said, "They open up a side of you that you aren't used to using. They have the skills to come with you on that journey."

Participants are a carefully balanced mix of people who bring different approaches to investigating and seeing the curriculum. They are required to take increasing personal responsibility for positive outcomes.

All participants work together as peers. Teachers cover all the STEM subjects and more, and have experience ranging from newly qualified to senior managers. Primary teachers are excited by secondary teachers' subject knowledge.

Secondary teachers want to experience primary teachers' whole curriculum approach. They rarely get to work together anywhere else.

The Lab framework is prepared in advance but it is expected to evolve as participants' interests take over. Considerable time is spent on creative challenges before we experiment with the curriculum. Sometimes teachers wonder why they can't get straight on with designing new curriculum materials but if they did, they would just repeat the known and comfortable patterns. Here, they discover that scientific analysis, creativity and imagination are all part of the same endeavour.

Together they tackle those aspects of STEM which are the most difficult to capture. By the end of the Lab, there are four or five projects, often lesson plans, which have been tested and are ready to show. On the last day, visitors experience and question the work-in-progress. Then the ideas are taken back into the classroom by confident teachers who are ready to innovate and inspire.

"The first two days of inspirational activities were so well planned in terms of what they made us think and in the last 24 hours we've been able to use those experiences in the way that we have developed our resources. My mind has been to places that it has never been before. It is the most inspiring thing I've ever done."

**Peter Smith,
Design & Technology Teacher**

PAL LAB OUTCOMES

PAL Labs always have tangible outcomes, not just in the schemes of work which participants take away, but also in changed pedagogical practice which endures for years. **Labs generate a long-term positive impact on teachers, their colleagues at school and their many year groups of pupils.**

It is important to acknowledge the significant impact on all participants in Labs, the teacher educators, curriculum developers, policymakers, scientists, designers and artists who collaborate as peers and gain new insights into their own work. A scientist on one of the Creative Science Teaching Labs went on to become a brilliant science communicator and PAL Lab Director. Another made a groundbreaking scientific discovery on his return to his own lab (see case study). And in early Labs, people whose work is in communicating science using digital and other media have integrated innovative ideas in their designs.

In the recent study by Ignition, **100% of teachers interviewed said the STEM Fluency Lab had made a positive difference, with 70% agreeing it made a big difference to their teaching of STEM subjects.** Lab participants have comprehensively embraced creative styles and strategies in their teaching.

Teachers become more confident, resilient and willing to let go of tightly controlled and prescribed working practices. Back at school they are willing to give their pupils permission to explore, innovate and become leaders in their own education.

"It's in the way I think about education. The way sometimes you go into a lesson and you start to teach and you think "Hang on a minute, whoa". And you take yourself back to the PAL Lab and lessons are 100% better".
Craig Bell, science teacher

There is a significant impact on teachers' ability to teach in an interdisciplinary way and to build cross-curricular STEM activities. All those in the study by Ignition agreed it had made a difference to their ability to build real work applications into lessons.

Lab participants share their experience in schools through materials, creative peer mentoring and training. For example, ideas from a STEM Fluency Lab have been included in a document of best practice made available to colleagues at school and across the region.

Teachers become more interested in their own continuing professional development and in making working links with other schools and higher education institutions. They strongly believe that the PAL approach should be rolled out more widely. The advocacy of teachers who attend Labs is a powerful testimony to their effect and impact.

"Participating teachers unanimously felt that the STEM Fluency Labs had a considerable impact on their approach to teaching STEM subjects, and in some cases this impact had been very strong indeed. Teachers were inspired and enthused by the concept of incorporating creativity into their lessons on a day to day basis."
Ignition, 2011

Impact on pupils

85% of those teachers recently surveyed said that they were confident that the impact of their participation in the Lab would make a difference in STEM pupil attainment.

Feedback from all the Labs over the past nine years shows that pupils' learning becomes more exciting and engaging. **There has been improved pupil attainment in tests** and we have had feedback telling us of an overall improvement in one school's grading for science teaching.

Typical feedback includes:

"We had very good results for my group after I had used the PAL technique in the revision programme. The feedback from the children has been good. One of the special needs boys came up and said how he now loved science and was looking forward to learning it in year seven."

"My results are consistently high, above where they should be and actually that must show that doing what I do in the classroom adds value. It adds value to learning and students learn well."

Examples of Lab participants' products

Growing Sound, a project that uses cross-curricular activities to teach music, physics and plant science.
www.growingsounds.sound101.org

The Nuffield STEM Games, activities to explore fitness, fairness, and the design of games and sports equipment.
www.nuffieldfoundation.org/stem

The Difference Engine, an interactive performance for family audiences, and curriculum resources for schools.
www.ioe.mmu.ac.uk/cue/

Ethical Emporium, a rich collection of resources for teaching ethics in the classroom.
www.windfalldigital.com/ethicalemporium

Case study

Andrei Khlobystov, associate professor in chemistry at Nottingham University, has taken part in two STEM Fluency Labs in 2009 and 2010. After the first, he spoke of his transformed approach to his research, inspired, he believes, by the Lab.

"I felt I had changed. When I came back to my lab I saw it as a different place. I decided to review data I had previously left to one side. I was sure there was something important there and I trawled them again over Christmas, unearthing concrete evidence to explain the mystery of why graphene transforms to the symmetrical and aesthetically pleasing carbon cages we know as fullerenes. This has now been published in Nature Chemistry."

Andrei Khlobystov

PAL LABS IN CREATIVE SCIENCE AND STEM

Science Simulation 2002 NESTA FutureLab commissioned PAL to bring together talented scientists, educators, 3D animators, media professionals and technologists. The aim was to discover how a range of simulations – from screen-based immersion to augmented reality and visualisation tools – might be used to illuminate key scientific concepts. **Ten different project demonstrations were created for science education through interactive simulation, from a five million dollar project on DNA to a computer-generated physical installation to find ‘the most blue skies’ in the world.**

Digital Science 2004 The Wellcome Trust and NESTA commissioned this Lab as the first stage in a two-year project to develop innovative teaching software project prototypes around social and ethical issues in 21st century science. **Twenty-four project ideas were developed at the Lab, six of which went on to receive further development funding.**

The Creative Science Teaching Lab programme 2002–05 brought together teachers from UK nursery, primary and secondary schools and teacher education to work with practising artists and scientists. The Labs provided unique opportunities to develop fresh thinking around teaching and learning practice in science. As the programme developed, some of the participants returned to the next Labs as mentors and, eventually, as PAL Lab Directors.

As Steve Mesure, PAL Creative Science Teaching and STEM Fluency Lab Director, said *“This is an incredible process – the teachers are given the time and space to unleash their creativity and to rediscover their reasons for teaching and their love of science.”*

PAL was encouraged by the momentum generated and the networks sustained by these Labs and could see that they were having an impact on teachers and on their pupils.

This was reinforced by independent academic evaluation by Anna Craft and Kerry Chappell.

PAL wanted to dig deeper into cross-curricular work and began to question design and technology which is characterised by its application of interdisciplinary subjects.

In 2006, during a meeting at the Qualifications and Curriculum Authority (as it then was) Mick Waters, Director of Curriculum, asked PAL this question **“How do we inspire teachers to understand that designing the future of learning is about more than new buildings?”**

We wondered what teachers – and policymakers – could learn from the different ways in which artists and designers see and create solutions? Our answer was a pilot Lab to introduce teachers and policymakers to imaginative design-based approaches to implementing the curriculum in schools. This was the **Design Fluency Lab**, directed by Caroline Nevejan from Amsterdam.

Teachers from schools in Knowsley Metropolitan Borough Council collaborated with artists, designers and a scientist to explore how space can be used in many different ways. After five days, **the teachers found that they could teach anywhere at all because what really matters is the quality of teaching and learning.** The PAL Lab teachers, as they called themselves, returned to Knowsley full of confidence and enthusiasm for the changes ahead. Several have gone on to senior positions in Knowsley’s new Learning Centres.



STEM Fluency Labs began as a commission from the Nuffield Curriculum Centre in 2008. Over five days teachers, artists and scientists worked together to generate new ideas for cross-curriculum resources for 11–14 year olds. Afterwards the Centre declared that **the Lab had generated enough work to keep them going for two years** – excellent value for money.

Post-Lab, the Centre worked with teachers to write and test **The Nuffield STEM Games**, activities to explore fitness, fairness, and the design of games and sports equipment.

These are now on:

www.nuffieldfoundation.org/stem

Dr Ray Mathias, PAL Lab Director, writes, *“My initial involvement with PAL was as a scientist-participant among the teachers, artists and scientists who made up the first Creative Science Teaching Lab. I became a firm advocate of this method of generating exciting, novel, cross-disciplinary and practical outcomes. In the two subsequent Labs I worked as a facilitator within the groups of participants. This deepened my appreciation of the creative and transformative nature of the Lab methodology.*

I was delighted to design and direct the 2008 pilot STEM Fluency Lab. I helped to deliver a collection of innovative, workable and engaging projects, which could be the starting point for developing cross-disciplinary STEM resources focused on the Olympics in 2012.”

Later that year the **Centre for Urban Education in Manchester** commissioned PAL to design a Lab for six teachers, five of CUE’s Creative Agents and six artists from theatre company **Walk the Plank**. They were starting to collaborate on a new theatre production, **The Difference Engine**, commissioned by Manchester International Festival and, in tandem, the development and testing of associated curriculum resources for primary and secondary school pupils. The project, which contained the PAL Lab, was directed by Helen Clare, who had participated in a PAL Creative Science Teaching Lab.

The Lab was the first opportunity for everyone to learn about each others’ areas of expertise and approaches to performance and learning. They worked together for three days on activities which stimulated their imaginations and their own individual and group creative thinking.

They liked the PAL Lab methodology, focused on making, **doing it first and then reflecting, rather than talking about it**, as so often happens elsewhere. Theatre was valued as a metaphor for what goes on in the classroom: the “wow” factor, excitement, surprise, having to do half the work (as any theatre audience does).

The Difference Engine performance (pictured) took place in the courtyard of Manchester Town Hall (during the Manchester International Festival in July 2009) and, later, in the Museum of Science and Industry. www.walktheplank.co.uk

The curriculum materials were published in November 2009. They helped teachers and pupils to explore the ideas generated by what was arguably the world’s first computer, in the 1830s. And pupils invented their own “difference engines” with some imaginative solutions to what they saw as deficiencies in design.

PAL LABS IN CREATIVE SCIENCE AND STEM CONTINUED

PAL's STEM Fluency Lab programme 2008-11 was produced in the East Midlands region with Ignite Futures, through its groundbreaking Ignition initiative. With the support of the East Midlands Development Agency and The Mighty Creatives, Ignition is a three-year, six-strand programme of creative activities and events designed to raise awareness, experience and aspiration in STEM. It is creating and nurturing young champions of science, technology, engineering and mathematics.

The PAL's STEM Fluency Lab programme is at the heart of Ignition's teacher development. There have been three five-day residential Labs, one each year, followed by non-residential reunions after several months.

Steve Measure, an experienced PAL Lab Director, led the first two Labs and supported Heidi Gale, a teacher participant in Lab one, who became co-director of Labs two and three. Steve was so inspired by the teachers that he went on to train and become a science teacher himself.

Fifty-four teachers have taken part in the STEM Fluency Labs and formed new collaborations, across schools, subjects and sectors and countries (there were two teachers from the USA) to make engaging and pupil-centred teaching and learning in STEM. By the end of the programme it is hoped that the PAL Lab methodology will have become part of the region's teacher development portfolio, to be improved and extended so it is always fresh and flourishing.



The immersive and regional aspects of the three-year Lab programme gave us a chance to understand how the powerful PAL Lab methodology impacts on teaching practice over a sustained period of time. The teachers are resilient and prepared to challenge the way they work and the context in which they are working. They are comfortable working across the curriculum in all subjects and can see new ways of making connections.



TEACHERS REFLECT

Heidi Gale, science teacher at The Nottingham Bluecoat School and Technology College and creative learning champion for Ignition.

"I participated in the first PAL/Ignition STEM Fluency Lab. It made me re-think everything I was doing, right down to the nuts and bolts and pedagogy of teaching and the value I add to pupils' experience."

At school I experimented with creative teaching and learning. I challenged the view that creativity is untidy, unplanned and has a lack of structure, which wouldn't fit in with today's expectations of classroom practice and control of learning. Managing the dynamic between freedom and process is an essential creative skill for excellent learning.

I began a new journey. Ignition sponsored me part-time to promote creative approaches to teaching and learning in STEM subjects. I became a creative learning champion with Ignition and remained part-time within my school. The role as creative learning champion has meant that I have been able to work with teachers across primary and secondary sectors in the region whilst maintaining my own experience in front-line teaching.

I co-directed the second and third STEM Fluency Labs in 2009 and 2010. The region now has a local centre of expertise in PAL Labs and I mentor and support teachers who are experimenting with new ideas for teaching and learning with pupils and with their peers.

I now feel better positioned as a teacher with a determined focus on how pupils are learning to learn. I am convinced that if you know what you want to achieve you don't have to plan every minute but you can hand over some responsibility, and risks, for the journey to young people."

Alice King, science teacher, The Robert Smyth School, Market Harborough participated in the first Lab. Two years later she reflects,

"To me science is a really creative subject, but as a new science teacher working with an established scheme of work it was not easy to be experimental. I emulated the creative aspects of the lessons in the scheme but they were not my ideas so I felt like I was playing a role in a play written by someone else."

In the STEM Fluency Lab I rediscovered my personal creative side, and found different mechanisms for getting across a point. It made me start to feel like a student again and made me realise the importance of teaching in a way that is engaging and relevant.

Back in school I now feel confident enough to spend a lesson painting a class picture to teach evolution or to throw the students the reins and entrust them to create a model to demonstrate the mechanisms of phagocytosis, instead of me standing at the front going through slides. My list of creative ways of teaching students includes making models of futuristic animals and plants to learn about natural selection through to simply starting students with key words from the last lesson to turn into a poem in five minutes.

Looking at a concept in science and re-creating it is what teaching is all about – ensuring students really do understand something and can explain it. This is hard work. Creativity is not all about fun, it is also about learning and not just copying someone else's version of the truth, but using the facts and evidence to create your own."

WHY PEOPLE COMMISSION PAL LABS

“The Nuffield Foundation’s decision to use PAL was based in the nature of the project: cross curricular STEM for 11–14 year olds. Working across departments presents a challenge for teachers. Curriculum development which asks teachers to cross domains requires them to change the way they think about the substance and approach of their practice. PAL provided the space and stimulus for teachers and developers to consider topics and learning approaches beyond the constraints of the normal school environment.”

Angela Hall
Director
Nuffield Foundation
Curriculum Programme

“PAL offers co-constructed thinking, the right minds, thinking things they hadn’t imagined, testing in a safe space, time, addressing a complex piece of work, and a deep level of questioning and reflection.”

Rehana Mughal
Creative Partnerships England

“The work we do with teachers as part of Ignition is key to its success in developing creativity in the teaching and learning of STEM subjects. PAL designed three Labs for teachers, artists and scientists with the explicit purpose of supporting all the participants to reveal and exercise their innate creativity. The Lab process was provocative and reflective, challenging and supportive in helping teachers define new creative approaches in their pedagogy. The design of Labs, with their emphasis on re-energising participants’ passion for their subjects, is what makes working with PAL uniquely rewarding.”

Rick Hall
Director of Programmes
Ignite Futures

PAL’S INVITATION TO YOU

PAL Labs make an impact that endures for years. Labs result in people who can sustain and develop their creativity in teaching and learning, inspiring their fellow teachers and, crucially, their pupils. Schools need inspired and imaginative teachers to ensure that teaching and learning is world class.

The impact of the PAL Lab methodology extends far beyond science, technology, engineering and maths in primary and secondary schools in the UK. PAL Labs are absolutely relevant to interdisciplinary teaching which embraces the whole curriculum and is lifelong. Young people can learn from the start that learning is about more than single subjects but is more to do with an appreciation of how things fit together and have meaning. After all, this is what adult life and work holds for them.

This is a global challenge and PAL Labs have resonance with what we know are commonly held concerns about STEM and about equipping young people for what are undoubtedly complex and demanding working and learning lives.

What are you struggling with?

- Finding solutions when even the questions are unclear in education today?
- Being sure that pupils are well equipped to meet the needs of the future?
- Designing education systems in which people are constantly on the lookout for innovative and inspiring approaches to teaching and learning?

PAL Labs are a timely response to change and uncertainty. We invite you to contact us and start a conversation about how we can help you.

What would you like to be doing that you’re not doing today?

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LAB TIMELINE

2001
**PILOT LAB
IN LEARNING**

2002
**LAB FOR TEACHER
EDUCATORS**
with Hogeschool,
Amsterdam

2002
**SCIENCE
SIMULATION LAB**
for NESTA FutureLab

2003
**CREATIVE SCIENCE
TEACHING LAB**
1 of 3

2005
**FAILING...
TO LEARN**
for schools'
senior managers

2004
**CREATIVE SCIENCE
TEACHING LAB**
2 of 3

2004
**DIGITAL
SCIENCE LAB**
for The Wellcome Trust
and NESTA

2003
**FOOD LAB
COLLOQUIUM**

2005
**LAB FOR FOOD
TECHNOLOGY
AND SCIENCE
TEACHERS**

2005
**LAB FOR ARTISTS
AND TEACHERS
WORKING IN
VOLATILE AND
CHALLENGING
SETTINGS**

2005
**CREATIVE SCIENCE
TEACHING LAB**
3 of 3

2006
**FAILING...
TO LEARN**
for one primary
school's staff team

2007
**DESIGN
FLUENCY LAB**
for QCA and
Knowsley MBC

2006
**COLLOQUIUM
ON TRAINING
FOR ARTISTS
AND TEACHERS
WORKING IN
VOLATILE AND
CHALLENGING
SETTINGS**

2006
**BRILLIANT SOUND
AND LIGHT LAB**
for Creative Partnerships,
Nuffield Theatre,
Southampton University
and secondary
school teachers

2006
**TWO PEDAGOGY
OF CURIOSITY
COLLOQUIA**
exploring the role
of sensory learning

2007
**ART, DESIGN AND
ECOLOGY LAB**
for the Centre
for Environmental
Education, India

2008
**CREATIVE
EXPLORATION LAB**
for St Mary's University
College, Belfast

2008
STEM FLUENCY LAB
for Nuffield
Curriculum Centre

2008
**STEM
FLUENCY LAB**
1 of 3, in East
Midlands, for Ignite

2010
STEM FLUENCY LAB
3 of 3, in East Midlands,
for Ignite

2010
**LAB FOR
CURRICULUM
POLICYMAKERS**
for QCDA

2009
**STEM
FLUENCY LAB**
2 of 3, in East Midlands,
for Ignite

2008
**DIFFERENCE
ENGINE LAB**
for Creative
Partnerships and
Walk the Plank



PAL

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