NEW PRINCIPLES FOR DESIGN & TECHNOLOGY in the National Curriculum
Acknowledgements

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With special thanks to the members of the D&T expert panel who are listed in the Annex.

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Executive Summary

The UK has an increasing shortage of technical skills in its workforce; a shortage that will seriously undermine the county’s economic growth.

Currently D&T is the only practical, hands-on, technical subject in the national curriculum in England. It is imperative that it remains as such, so that it can introduce young people to the knowledge and skills needed for creative design, innovation and engineering. D&T is not a vocational subject. It is a general academic subject and has its own fundamental body of knowledge, principles and concepts which are not provided elsewhere in the curriculum. But the subject is in need of reform to bring it in line with current Design thinking and modern technologies – a view shared by the D&T community. In this document we propose a new model for the D&T that realigns the subject with the original progressive vision proposed when it was introduced in 1989 while making it relevant for the 21st century.

The model sets out an overarching set of concepts and principles that can be applied to any aspect of D&T regardless of the medium in which the pupils are working. Using key concepts and principles, the approach will create a shift in emphasis from teaching separate sub-disciplines to a more coherent curriculum for D&T.

Through the application of key concepts and principles across the different sub-disciplines, the ambition is to create a holistic subject that develops well-rounded individuals who are cognisant of the designed and made world around them and are able to apply their knowledge and skills to provide solutions to a variety of needs, wants and opportunities.

In keeping with the practical nature of D&T, we have called this approach the Design and Technology Toolbox, shown in Figure 1. The D&T Toolbox is split into four groups: Design, Technology, Critique and Data. A more detailed view of the toolbox is presented in Figure 2 in the main body of the report. This bodies of knowledge approach is applicable to primary and secondary schools, but the diagram and list of tools presented here is the sum of all learning and is applicable specifically to KS3. In due course we intend to illustrate how the approach would look in KS1 and KS2 through a version of the diagram and list of tools appropriate for primary schools.

In each group, a series of key concepts and principles are presented. For example, within the designing group there are key concepts around; designing for people such as clients and users; identifying needs and wants and exploring market opportunities. There are also principles of visualisation of designs in 2D, 3D on paper and through Computer Aided Design. In the technology group, concepts and principles include understanding materials properties, shaping materials and also providing power and useful energy storage. All the concepts and principles are provided in more detail in the main body of the report.

E4E launches this report during the public consultation phase of the National Curriculum Review and we will present this document as an alternative model for developing the Programme of Study for D&T. We hope you will support this model and highlight it in your responses to the consultation.

FIGURE 1: The D&T Toolbox (summary view)
**Introduction**

This document presents suggested principles on which the Programmes of Study for Design and Technology in the National Curriculum should be based.

For this report, E4E brought together an expert group, comprising Higher Education academics, representatives from Industry, senior school leaders, D&T subject specialists from outstanding schools across England and members of the Design and Technology Association (D&TA) and the engineering profession to discuss the strengths and weaknesses of the current D&T curriculum and to develop a vision of the core principles that would deliver a high quality D&T experience in schools in the 21st Century.

This report brings together the views of the expert group and presents a new approach to concepts and principles for Design and Technology education for the National Curriculum Review in England.
Design & Technology in the National Curriculum

Design and Technology has been a part of the National Curriculum since 1989. Its formation and the evolution of the subject from traditional craft aspects such as woodwork, metalwork, home economics and sewing towards a more design centred approach was an education policy innovation.

The then Secretary of State for Education, Rt Hon Kenneth Baker MP welcomed the visionary work, led by Lady Margaret Parks, and commented that it set out a coherent and persuasive view of design & technology as an essentially practical activity, concerned with developing pupils’ competence to tackle a wide variety of problems, drawing on a broad base of knowledge and skills. The subject has enjoyed strong support from successive governments. Pupils have also enjoyed the subject and today it is still the most popular non-compulsory GCSE.

On the 20th January 2011, the Secretary of State for Education, Rt. Hon. Michael Gove MP announced a review of the primary and secondary National Curriculum in England. The intention of the review is to replace the current curriculum with one based on the best school systems in the world. Since then the future of D&T has been under threat as the National Curriculum is slimmed down, setting out only the essential knowledge for pupils.

The future of D&T was put further in doubt when the Expert Panel of the National Curriculum Review, appointed to advise Government on the new curriculum, recommended in its December 2011 report that D&T should be taken out of the new national curriculum and placed in a basic curriculum. This move would ensure that pupils would be entitled to be taught the subject but the nature and extent of that provision would be determined by schools individually and locally according to their needs.

The Government did not follow this recommendation and published in February 2013 the draft Programmes of Study for D&T in the National Curriculum for Key Stages 1–3. However, the draft programmes of study published by the Department for Education have significantly shifted the direction of the subject from the statutory programmes of study currently in force, developed from the original National curriculum requirements in 1989. In place of a design-centred curriculum, there is now a strong emphasis on practical life skills. We recognise the importance of life skills for children and young people but strongly oppose the way they are positioned within the draft D&T curriculum. The technology aspects of the proposed curriculum have also changed substantially, with a focus on diagnostics and maintenance rather than design and development.

The draft programme of study that has been published is not the direction of reform for the subject that is needed for the 21st century, to ensure the UK builds the right knowledge and skills in technology, innovation and engineering to support economic growth in the productive and creative industries. We highlight below why D&T is important and set out a new approach for the subject for the national curriculum.
Why is Design & Technology important?

Design and Technology is one of the few subjects in the curriculum where pupils confront and solve problems where there is no right answer. Through D&T pupils learn to deal with ambiguity; undertaking tasks without all the information necessary to complete them from the outset. Learning to cope with ambiguity is an important characteristic of the well-educated person. It empowers learners and develops self-confidence.

D&T is one of the very few opportunities for pupils to partake in a technical, practical education. It plays an important role in providing young people with a hands-on, creative experience and develops a practical identity and a capability for innovation. The subject provides opportunity for collaboration, team working and communication – skills that are essential for future employment. It is the closest subject to engineering in the National Curriculum.

D&T is not a vocational subject. It is a general academic subject, and has its own fundamental body of knowledge, principles and concepts which are not provided elsewhere in the curriculum\(^1\). However, D&T is about much more than simply knowledge. It enables higher level cognitive skills to be developed in the learner – developing hypotheses, synthesis of ideas and reflection. D&T also provides an opportunity for examination and critical evaluation of the made world. It offers the opportunity for pupils to investigate and evaluate the use of materials in products and designs and the consequent depletion of the earth’s natural resources. D&T is the most suitably placed primary and lower secondary school subject to examine humanity’s use of, and consumption of finite resources and the methods by which we may investigate sustainability, recycling and re-use of materials in linear and circular economies.

As such D&T provides an essential and unique component for the education of all young people whatever their eventual employment.

In addition to its own body of knowledge, D&T should also include practical application of underpinning concepts from science (in particular physics but increasingly chemistry and biology) and mathematics. It is an excellent opportunity to embed and apply the concepts in these subjects in practical applications. D&T has the ability to deepen understanding of physical principles through modelling and testing. D&T could also play a significant role in improving the role of computing in schools.

D&T supports the UK economy by helping to prime young people and develop skills in creativity, innovation and engineering. It is one of the few subjects in school from where young people can have a truly authentic experience of a practical work environment and it is therefore a subject through which the UK can grow its future designers and engineers at all levels. It is an important subject for children who are considering pursuing careers in the design and engineering sectors and who could contribute to a rebalanced economy at the heart of the Government’s growth strategy.

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\(^1\) For example see: The Continuum of design education for engineering (Geoffrey Harrison. Engineering Council and EEF, the manufacturers’ organisation) http://www.data.org.uk/generaldocs/dater/continuum.pdf and RECORDAT (http://webarchive.nationalarchives.gov.uk/20100202100434/qcda.gov.uk/3312.aspx)
Current provision in Design & Technology

Today, as with many subjects, the current quality of D&T in schools varies. Ofsted found in its most recent report outstanding and good provision in D&T in many primary and secondary schools but was clear that there was a need to ensure that all English schools kept pace with technological advancements. An independent study undertaken for the Royal Society of Arts, Crafts and Manufacturers (RSA) found examples of too little creativity and of formulaic design education in current D&T lessons. These issues are in part due to timetabling constraints and cost of capital equipment and consumables.

However, we believe that a significant part of the current problem of D&T is the way in which the disparate aspects of the subject are often taught in isolation; resistant materials, food technology, textiles, systems and control etc. This does not reflect the true nature of the designing and so we believe a new approach is required. The D&T community have recognised the need to reform the subject to align it with modern design thinking and industrial practices while maintaining the original vision established with the introduction of the subject.

A new approach to Design & Technology

We believe that in revising the National Curriculum there is an excellent and positive opportunity to bring coherence to the experience of learners within D&T and more broadly across Science, Technology, Engineering and Mathematics (STEM) subjects.

Coherence across STEM subjects

The separation of STEM subjects including ICT and D&T is convenient in education as it falls within current school timetabling structures, the fundamentals of which have changed little in decades, as this suits contemporary school organisation, cultures and practices.

However, it is an artificial separation and only serves school organisation. It does not support the needs of learners in this century of dynamic/creative learning opportunities and in a globally competitive economy.

By addressing this and creating an integrated key-stage by key-stage curriculum, only then will pupils have unrivalled opportunities to understand the relevance of, and apply mathematical, scientific, design and computing concepts to the made-world. This should be the ultimate aim of the formative STEM curricula which will serve students best and multiply the number of home grown knowledgeable and highly skilled young people in the UK.

To this end, content in D&T that relies on mathematics and science should be taught at a similar time (or soon after) the necessary mathematical and scientific ideas have been covered in those subjects. That time should be determined by the age at which the concepts can be securely grasped. The use of scientific and mathematical concepts and principles in real-world applications through D&T will serve to reinforce the content and provide meaning and relevance to potentially otherwise abstract knowledge.

Through D&T, there are also links to other subjects such as Citizenship, Geography, History and Business Studies and of course Art and Design.

Design & Technology should be taught allowing time for exploration, experimentation, equivocal outcomes and the increasing empowerment for pupils to learn for themselves, when it is appropriate and when sufficient fundamental knowledge has been acquired.

Coherence in the D&T curriculum

A coherent curriculum for D&T should provide a solid, integrated understanding of the key concepts of Design and Technology across all sub-disciplines within the subject. It should set out the overarching concepts and principles which can be applied, regardless of the medium in which pupils are working. For example, the concept of structure can be applied, demonstrated and explored equally in textiles as it can in metallic or plastic artefacts.

This new method of presenting the fundamental concepts and principles of D&T would present opportunities for more exciting pupil exercises across different media but will require teachers, particularly in secondary education, to take a more collaborative and holistic view of D&T rather than focus on their individual specialist areas.

A coherent curriculum in D&T would introduce the concepts and principles at the appropriate key stages. At the end of a given period (e.g. year or Key Stage) the content should come together to form a coherent and consistent whole. This could then be developed and built upon in later years. In the next section, we propose a model as a guide for how principles and concepts may be presented, so that they bridge across individual sub-disciplines within D&T as well as Science and Mathematics when appropriate.

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5 It should also be noted that there will be certain concepts, principles and knowledge that would not be applicable to all sub-disciplines.
Key Concepts for Design & Technology

The Key Concepts approach for D&T represents a shift in emphasis away from teaching separate sub-disciplines; food technology, resistant materials, textiles, graphics, systems and control, electronics and so on, to a more coherent approach. This model sets out an overarching set of principles that can be applied to many of the media in which pupils are working. However, we acknowledge that in some instances, the key concepts cannot be transferred easily from one medium to another.

The Key Concepts model is made up of four different families or bodies of knowledge which the learner can use to develop ideas.

This bodies of knowledge approach is applicable to both primary and secondary schools, but the diagram and list of tools presented here is the sum of all learning and is therefore applicable specifically to KS3. In due course we intend to illustrate how the approach would look in KS1 and KS2 through a version of the diagram and list of tools appropriate for primary schools.

In keeping with the practical nature of Design and Technology we have termed this model the D&T Toolbox. This is shown in Figure 2.

The Key Concepts presented below in the D&T toolbox are not intended as a complete specification for the subject. Rather, the aspiration is for the concepts to be used as a menu to create a holistic curriculum to develop well-rounded individuals who are cognisant of the designed and made world around them and to be able to apply their knowledge to solve needs, wants and opportunities.

The Design & Technology Toolbox

The D&T Toolbox consists of four sections: Design, Technology, Critique and Data. In each of these sections, the key concepts and principles are tools which pupils can use to develop their understanding of the designed and made world. Pupils can apply these tools as and where appropriate to their own design-and-make creations. The following sections provide details on the typical aspects of the curriculum that might be experienced by pupils through this approach.

FIGURE 2: The Design & Technology Toolbox – detail view
Design

Pupils should understand that designing involves responding to a need, want, revision or new opportunity by generating a concept that is then developed and refined to the point where it can be brought into physical existence as part of the made world.

The nature of the designed outcome will be shaped by a wide range of influences: aesthetic, technical, economic, environmental, ethical and social. Depending on the interplay of these influences, widely differing design proposals may be generated in response to a particular situation. Whether such proposals are appropriate and fit for purpose is then a matter of judgement. This requires pupils to evaluate and reflect on their ideas, designs and artefacts.

Pupils should understand that designing and making is reflected in, and influences cultures and societies, and designed products should have a positive impact on lifestyle. The dimensions above (aesthetic, technical, economic etc.) interact to shape designing and making.

Tools for Designing for people: clients and users

Maintaining the designer client relationship

Pupils should know about and be able to:
- Use tools to communicate ideas to clients e.g. visualisations on paper and on screen.
- Use tools for costing their design proposals in the light of different economic conditions.
- Use tools for innovating e.g. commissioning (proposals, prototypes, production) developing different business models, establishing intellectual property.

Exploring market opportunities

Pupils should know about and be able to:
- Use tools for branding e.g. to establish a visual identity, to elicit emotional response and establish loyalty.
- Use tools for marketing e.g. for product presentation, for product promotion.
- Understand that the work of past designers can influence the development of new designs and design thinking.
- Understand the benefits of interdisciplinary approaches, bringing together ideas from art, engineering, maths, and sciences and technology.

Identifying needs and wants

Pupils should know about and be able to:
- Use tools for collecting data about users e.g. observing, recording, questioning, interviewing.
- Use tools for analysing and interpreting the data to identify needs, wants and opportunities.
- Use tools for developing briefs and specifications such that these incorporate different design requirements e.g. for ease of maintenance, disassembly, rapid manufacture, recovery within a circular economy.

Tools for generating and developing design ideas

Generating design ideas

Pupils should know about and be able to:
- Use two dimensional geometric forms such as straight line and curved polygons (for example triangle, square, hexagon, parallelogram, circle, crescent, annulus etc.) and three dimensional forms (cube, prism, sphere, cylinder etc.) to inform their design decisions.
- Develop patterns and manipulate geometric forms through translation, reflection, rotation and tessellation.
- Use tools for generating ideas e.g. discussing, brainstorming, attribute analysis, bio mimicry, forcing connections, design history, image and stimulus boards.
- Use tools for learning from existing technologies e.g. disassembly & reassembly / reverse engineering / product analysis/datasheets
- Use new and emerging technologies as starting points for designing.

Developing design ideas

Pupils should know about and be able to:
- Use tools for modelling performance (including structural, ergonomic, control, maintenance, repair) e.g. on paper, in 3D, on screen (CAD).
- Use tools for planning and coping with uncertainty e.g. listing, Gantt charts, and flow charts.
- Use tools for systems thinking e.g. block diagrams describing input, process, output and feedback, truth tables, flowcharts, simulation.
- Use tools for evaluating their designs against performance specification criteria, production specification criteria and user response.
Technology

Pupils should understand that technological activity involves the use of practical and intellectual resources to develop products and systems that expand human possibilities by addressing needs and taking opportunities. Innovation and adaptation are fundamental to technological practice. Technological thinking should be informed, critical and creative if it is to lead to desirable outcomes. Technology has its own particular knowledge and skills, and uses those of other disciplines in pursuing its purposes.

Technology always has consequences, known and unknown, intended and unintended.

Technology is never static. It is influenced by and in turn impacts on the cultural, social, ethical, environmental, political, and economic conditions of the day.

Tools for making things

Understanding materials and their properties

Pupils should know about and be able to:

- Identify and work with different materials. Materials which they might work with during their work include: paper and card, fabrics, metals and alloys, timbers and timber products, polymers, ceramics, composites, modern and smart materials, organic materials, food stuffs. Pupils should be able to understand that different materials have different properties and these properties affect the characteristics of the materials.

- Understand a range of material properties e.g. mechanical, thermal, electrical, magnetic, optical, chemical, nutritional and sensory. Pupils should be able to use information about the properties of materials to decide on which materials to use for particular applications.

- Understand that increasingly nanotechnology is used to produce materials with exceptional properties e.g. graphene

- Understand that synthetic biology is an emerging engineering discipline which aims to redesign biological systems often to produce materials with exceptional properties and complex chemical/biological products such as synthetic hydrocarbon fuels, synthetic spider silk, and marker molecules for use in medical diagnostic procedures.

Processing and Shaping Materials

Pupils should know about and be able to:

- Use a range of processes that enable them to realise a design in a three dimensional form. This may include measuring, cutting, shaping, forming, casting, machining, combining, additive layer manufacturing and various finishing processes such as painting and surface coating etc.

- Appropriately and correctly undertake a range of processes using hand tools, power tools, machine tools, programmable and computer numerical control (CNC) and computer aided manufacturing (CAM) and apply these as necessary when fabricating their design ideas.
Tools for making things work

Providing power and storing energy

Pupils should know about and be able to:

- Develop an understanding of how to choose and use appropriate methods of power to make their devices work.
- Use useful energy storage for mechanical, electrical, chemical and fluidic power. These could include springs, batteries, combustion fuels and pressurised containers.

Understanding structures and mechanisms

Pupils should know about and be able to:

- Work with a range of structural elements e.g. struts, ties, beams, cantilevers, columns, plates, arches, shells and how they might be joined through the use of joints and fastenings.
- Combine materials to create desired structural and other properties.
- Learn how to use their knowledge of structures to decide on the form of the products they design and make.
- Understand how components within a mechanical product can move relative to each other. Mechanisms enable various movements including rotary, linear, oscillating and reciprocal. Mechanisms include but are not limited to gears, worms, wheels, levers, rotating shafts, cams, pulleys and cranks.
- Apply appropriate mechanisms to their designs where applicable.

Controlling devices and systems

Pupils should know about and be able to:

- Use a range of methods of control. This might be controlling movements by means of mechanical systems that produce different sorts of movement and change the size, direction and point of application of forces and motions;
- Make electronic circuits to control the production of heat, light, sound and movement.
- Draw on knowledge from computer science aspects of ICT to write computer programs to control devices, along with associated electronics to develop embedded machine intelligence that responds to a range of inputs (e.g. from sensors) and controls the electronic signals to a range of outputs (e.g. actuators) using, for example, Peripheral Interface Controllers (PICs)
- Choose and use methods of control including those requiring feedback for the products they design and make. Examples of control include mechanical control such as a simple water tap controlling the flow of water, or electronic control such as a volume knob controlling the loudness of the radio. More complex electrical and mechanical control systems ‘feed-back’ information to ensure appropriate control. For example, an electric kettle turns off when the desired temperature is reached.
- The making of materials using synthetic biological systems e.g. synthetic spider silk, synthetic hydrocarbon fuels and marker molecules in medical therapies.

Critique

Pupils should understand that critiquing involves standing back and looking at the outcomes of design, technology and engineering making an assessment of their worth from a variety of perspectives e.g. global, social, cultural, economic and environmental.

Tools for stewardship

Using Life Cycle Analysis

Pupils should know about and be able to:

- Use life cycle analysis to track the effect of a product on the environment and finite resource depletion.

Considering linear and circular economies

Pupils should know about and be able to:

- Consider the consequences of both economic models.
- Consider the impact of exceptional material uses.

Tools for impact analysis

Identifying winners and losers

Pupils should know about and be able to:

- Use the idea that all technologies have consequences and their use leads to some groups gaining and some losing.
- Understand how technology is available to different groups and that some groups may be disadvantaged through lack of access.
- How the significant advances in technology have changed society and will change society in the future.
Considering local, regional and global effects

Pupils should know about and be able to:

- Use tools for modelling social, environmental and cultural impacts of technology.
- Understand how planetary boundaries can be used to identify tipping points.

Data

Using data to inform a design is a critical part of any design process, whether it is undertaking customer surveys to design new furniture, taking measurements to design a kitchen or undertaking experiments to design the appropriate shape of an aeroplane wing.

Pupils should be exposed to the various types of data collection methods. For certain aspects of data handling, there is likely to be some overlap with the Tools for Designing for people: clients and users.

Tools for interpreting data

From investigations of others

Pupils should know about and be able to:

- Use data from investigations by others including that obtained by large-scale data mining to inform their design decisions.

Tools for interpreting data

Using geometry and algebra

Pupils should know about and be able to:

- Apply and adapt algebraic formulae to inform their design decisions.
- Use graphical techniques to inform their design decisions - for example, satellite dishes use parabolic curves to optimise the reception.

Using statistics

Pupils should know about and be able to:

- Use the statistical techniques to inform their design decisions. Methods such as averaging, means, distributions, scattergrams, probability to inform their design decisions.
- Use programming to refine and make sense of digital data.
Next Steps

This report presents a new stimulating and challenging approach for D&T in schools and heralds a dramatic shift, requiring new teaching practices and demanding imaginative curriculum and timetabling solutions in a new era of education.

Recent legislation means that this transformation is well within the present capability of most schools. Issues to be raised by schools will include resource shortages for Continuous Professional Development (CPD), hardware, software costs and refining spaces or studios in which to teach. Schools where training and dynamic curriculum development structures are well established and continual development is a cultural norm will adapt relatively quickly and most easily.

As a consequence, a section of their normal Review and CPD will be re-cycled into D&T redesign, ameliorating a portion of the cost. Any additional money required can be directed at the higher end training needs of schools such as new technologies, electronics and computing, in which much of the success of this holistic approach is rooted.

We thank the expert panel for providing the ideas that led to this document. The work has highlighted the fundamental necessity of close contact between senior employers, higher education academics and school leaders so that the needs of industry and HE are understood in schools and the needs of schools are also recognised by employers.

We now ask the government to be bold and recognise the draft Programme of Study is not right for a 21st Design and Technology curriculum and not right for the needs of creative and productive sectors of the UK economy.

We welcome the opportunity to discuss this report with the Department for Education and we ask that you highlight this model as an alternative approach to the D&T programme of study in your responses to the consultation of the national curriculum review.
Annex: Membership of expert panel

The members of the review panel were selected from schools, Higher Education, industry and the design & technology community. They were:

**Dr David Barlex**
Curriculum Consultant to the Design & Technology Association. Visiting Lecturer Roehampton University

**Stuart Douglas**
Assistant Head/HOD/AST/Lead practitioner Ripley St Thomas CE High, Lancaster

**Rod Dyson**
Assistant Head and Director of Engineering Skipton Girls High School, North Yorkshire

**Richard Earp**
Education & Skills Manager at National Grid

**Mike Ive OBE HMI**
Design and Technology Education Consultant, former Subject Adviser to Ofsted for D&T. Lead Assessor Engineering Specialist Schools. Trustee: Design & Technology Association, Young Engineers.

**Rebecca Higgins**
D & T Subject Leader Newtown CE Primary School, Newtown, Wem, Shropshire

**Les Jones (Convener and Chair)**
Chief Executive Solutions 4 Schools/The Engineering Company (Europe)

**Prof Richard Kimbell**
Emeritus Professor of Technology Education Goldsmiths College University of London.

**Dr Peter Long**
Mechanics and Materials Division Department of Engineering Cambridge University

**Dr Adrian Miller**
Assistant Head Teacher and Director of Engineering Samuel Whitbread Community College, Bedfordshire

**Andy Mitchell**
Assistant Chief Executive at the D&T Association

**Dominic Nolan**
Manager STEM Curricula Royal Academy of Engineering

**Gareth Pimley**
Primary Education Consultant

**Susan Scurlock**
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**Karen Wells**
Director of D&T and Science Soham College, Cambridgeshire

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NEW PRINCIPLES FOR DESIGN & TECHNOLOGY
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