Differentiaiting Applied Research and Experimental Development

Extract from OECD Frascati Manual 2015, p 50-57.

Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives. It involves considering the available knowledge and its extension in order to solve actual problems. In the business enterprise sector, the distinction between basic and applied research is often marked by the creation of a new project to explore promising results of a basic research programme (moving from a long-term to a medium-short term perspective in the exploitation of the results of intramural R&D). The results of applied research are intended primarily to be valid for possible applications to products, operations, methods or systems. Applied research gives operational form to ideas. The applications of the knowledge derived can be protected by intellectual property instruments, including secrecy.

Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.
The development of new products or processes qualifies as experimental development if it meets the criteria for identifying R&D activity.

Experimental development is not

- "product development"

The concept of experimental development should not be confused with "product development", which is the overall process – from the formulation of ideas and concepts to commercialisation – aimed at bringing a new product (good or service) to the market. Experimental development is just one possible stage in the product development process: that stage when generic knowledge is actually tested for the specific applications needed to bring such a process to a successful end. During the experimental development stage new knowledge is generated, and that stage comes to an end when
the R&D criteria (novel, uncertain, creative, systematic, and transferable and/or reproducible) no longer apply. As an example, in a process aimed at developing a new car, the option to adopt some technologies could be taken into consideration and tested for use in the car under development: this is the stage when experimental development is performed. It will lead to new results by dealing with new applications of some general knowledge; it will be uncertain, because testing could give rise to negative results; it will have to be creative, as the activity will focus on the adaptation of some technology to a new use; it will be formalised, by needing the commitment of a specialised workforce; and it will involve a codification, in order to translate the results of the tests into technical recommendations for the further stages of the product development process. However, there are cases of product development without R&D that are discussed in the economics literature, especially in the case of SMEs.

- "pre-production development"

The concept of experimental development should not be confused with "pre-production development", which is the term used to describe nonexperimental work on a defence or aerospace product or system before it goes into production. Similar cases apply in other industries. It is difficult to define precisely the cut-off point between experimental development and preproduction development; the distinction between these two categories requires "engineering judgement" as to when the element of novelty ceases and the work changes to routine development of an integrated system.

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For example, once a fighter bomber has successfully passed through the stages of research, technology demonstration, project design and initial development to the flight-testing of a pre-production aircraft, up to ten additional airframes may be required in order to ensure full operational integration of the vehicle into air offence/defence systems. This would be a two-stage process. The
first stage is development of the integrated air offence/defence system, which involves bringing together developed components and subsystems that have not previously been integrated in this context. It requires a large flight test programme for the aircraft, which is potentially very expensive and the main cost element prior to production. While much of the work commissioned during this stage is experimental development (R&D), some does not have the element of novelty necessary for classification as R&D and is instead pre-production development (non-R&D). The second stage covers trials of the integrated air offence/defence system. Once the system is proven to work at stage one, the development project may move on to produce a trial production batch for operational trials (low-rate initial production). The full production order depends on their success. According to this manual, this work is not R&D but pre-production development. However, problems may arise during the trials, and new experimental development may be needed to solve them. This work is described in this manual as "feedback R&D" and should be included as R&D.

Examples of how to differentiate types of R&D in the natural sciences and engineering

The following examples illustrate general differences between Basic and applied research and experimental development. In the social sciences, humanities and the arts the blurring of boundaries could affect the distinction between basic and applied research. Examples of experimental development in these domains can also be difficult to identify, because of the role played by other domains in the natural sciences and engineering. It should be noted that these examples must also meet the basic criteria identified in this chapter to be considered as R&D.

In the natural sciences and engineering

- Basic research: The study of a given class of polymerisation reactions under various conditions is basic research.
- Applied research: The attempt to optimise one of these reactions with respect to the production of polymers with given physical or mechanical properties (making it of particular utility) is applied research.
- Experimental development: Experimental development then consists of "scaling up" the process that has been optimised at the laboratory level and investigating and evaluating possible methods of producing the polymer as well as products to be made from it.

- Basic research: The modelling of a crystal's absorption of electromagnetic radiation is basic research.
- Applied research: The study of the absorption of electromagnetic radiation by this material under varying conditions (for instance, temperature, impurities, concentration, etc.) to obtain given properties of radiation detection (sensitivity, rapidity, etc.) is applied research.
- Experimental development: Testing a new device using this material in order to obtain a better detector of radiation than those already existing (in the spectral range considered) is experimental development.

- Basic research: The development of a new method for the classification of immunoglobulin sequences is basic research.
- Applied research: Investigations undertaken in an effort to distinguish between antibodies for various diseases is applied research.
- Experimental development: Experimental development then consists of devising a method for synthesising the antibody for a particular disease on the basis of knowledge of its structure and

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clinical tests of the effectiveness of the synthesised antibody on patients who have agreed to accept an experimental advanced treatment.

- Basic research: A study about how the properties of carbon fibres could change according to their relative position and orientation within a structure is basic research.
- Applied research: The conceptualisation of a method to allow for processing carbon fibres at industrial level with a degree of precision at the nano-scale could be the outcome of some applied research.
- Experimental development: Testing the use of new composite materials for different purposes is experimental development.

- Basic research: Controlling material processes in the domain where quantum effects occur is an objective to be pursued through basic research.
- Applied research: Developing materials and components for inorganic and organic light-emitting diodes for improved efficiency and cost reduction is applied research.
- Experimental development: Experimental development could be aimed at identifying applications for advanced diodes and incorporating them in consumer devices.

- Basic research: Searching for alternative methods of computation, such as quantum computation and quantum information theory, is basic research.
- Applied research: Investigation into the application of information processing in new fields or in new ways (e.g. developing a new programming language, new operating systems, program generators, etc.) and investigation into the application of information processing to develop tools such as geographical information and expert systems are applied research.
- Experimental development: Development of new applications software and substantial improvements to operating systems and application programmes are experimental development.

- Basic research: The study of sources of all kinds (manuscripts, documents, monuments, works of art, buildings, etc.) in order to better comprehend historical phenomena (the political, social, cultural development of a country, the biography of an individual, etc.) is basic research.
- Applied research: Comparative analysis of archaeological sites and/or monuments displaying similarities and ohter common characteristics (e.g. geographic, architectural, etc.) to understand interconnections of potential relevance to teaching material and muuseum displays is applied research.
- Experimental development: The development of new instruments and methods for studying artefacts and natural objects recovered through archaeological endeavours (e.g. for the age-dating of bones or botanic remains) is experimental development.

In agricultural sciences and forestry

- Basic research: Researchers investigate genome changes and mutagenic factors in plants to understand their effects on the phenome. Researchers investigate the genetics of the species of plants in a forest in an attempt to understand natural controls for disease or pest resistance.
- Applied research: Researchers investigate wild potato genomes to locate the genes responsible for resistance to potato blight in an effort to improve the disease resistance in domestic/crop potatoes. Researchers plant experimental forests where they alter the spacing and alignment of the trees to reduce the spread of disease while ensuring the optimum arrangement for maximum yield.

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- Experimental development: Researchers create a tool for gene editing by using knowledge of how enzymes edit DNA. Researchers use existing research on a specific plant species to create a plan for improving how a company plants its forests to achieve a specific goal.

In nanotechnology

- Basic research: Researchers study the electrical properties of graphene by using a scanning tunnelling microscope to investigate how electrons move in the material in response to voltage changes.
- Applied research: Researchers study microwaves and thermal coupling with nanoparticles to properly align and sort carbon nanotubes.
- Experimental development: Researchers use research in micromanufacturing to develop a portable and modular micro-factory system with components that are each a key part of an assembly line.

In computer and information sciences

- Basic research: Research on the properties of general algorithms for handling large amounts of real-time data.
- Applied research: Research to find ways to reduce the amount of spam by understanding the whole structure or business model of spam, what spammers do, and their motivations in spamming.
- Experimental development: A start-up company takes code developed by researchers and develops the business case for the resulting software product for improved on-line marketing.

In economics and business

- Basic research: A review of theories on the factors determining regionaal disparities in economic growth. Economists conducting abstract research in economic theory that focuses on whether a natural equilibrium exists in a market economy. The development of new risk theories.
- Applied research: The analysis of a specific regional case for the purpose of developing government policies. Economists investigating the properties of an auction mechanism that could be relevant to auctioning the telecommunications spectrum. The investigation of new types of insurance contracts to cover new market risks or new types of savings instruments.
- Experimental development: The development of operational models, based upon statistical evidence, to design economic policy tools to allow a region to catch up in terms of growth. The development by a national telecommunications authority of a method for auctioning the telecommunications spectrum. The development of a new method to manage an investment fund is experimental development as long as there is sufficient evidence of novelty.

In education

- Basic research: Analysis of the environmental determinants of learning ability. The investigation by researchers of the effect of different types of manipulatives on the way first graders learn mathematical strategy by changing manipulatives and then measuring what students have learned through standardised instruments.
- Applied research: The comparative evaluation of national education programmes aimed at reducing the learning gap experienced by disadvantaged communities. The study by researchers of the implementation of a specific math curriculum to determine what teachers needed to know to implement the curriculum successfully.
- Experimental development: The development of tests for selecting which educational programme should be used for children with specific needs. The development and testing (in a classroom) of software and support tools, based on fieldwork, to improve mathematics cognition for student special education.

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In social and economic geography

- Basic research: Researchers seek to understand the fundamental dynamics of spatial interactions.
- Applied research: A research study analyses the spatial-temporal patterns in the transmission and diffusion of an infectious disease outbreak.

In history

- Basic research: Historians study the history and human impact of glacial outburst floods in a country.
- Applied research: Historians examine past societies' responses to catastrophic natural events (e.g. floods, droughts, epidemics) in order to understand how contemporary society might better respond to globaal climate change.
- Experimental development: Using previous research findings, historians design a new museum exhibit on the adaptations of past human societies to environmental changes; this serves as a prototype for other museums and educational installations.

In language/linguistics

- Basic research: Linguists study how different languages interact as they come into contact with one another.
- Applied research: Speech therapists examine the governing neurology of languages and how humans acquire language skills.
- Experimental development: Linguists develop a tool for diagnosing autism in children based on their language acquisition, retention and use of signs.

In music

- Basic research: Researchers develop a transformational theory that provides a framework for understanding musical events not as a collection of objects that have particular relationships to each other but as a series of transformational operations applied to the basic material of the work.
- Applied research: Researchers use historical records and the techniques of experimental archaeology to recreate an ancient and long-disappeared musical instrument and to determine how it would have been constructed, how it was played and the types of sounds it would have produced.
- Experimental development: Music educators and theorists work to produce new pedagogical materials based on new discoveries in neuroscience that change our understanding of how humans process new sounds and information.

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