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Cycles and Affine Subschemes in the Applied Research Process

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Abstract
Can cycles in research refine the research? Yes, cycles in research are essential for refining the research process and its findings. Research is not a linear, one-and-done process but an iterative and recursive cycle of continuous improvement. Each cycle or iteration builds upon the last, allowing researchers to refine their methods, test assumptions, and produce more accurate and reliable result. Then the initial cycle of the commutative diagram of the research method by fundaments that is isomorphic to a subtheory is such an affine subscheme, which is isomorphic to the spectrum of the ring of the studied research method. A corollary is obtained in the electronics and quantum field theory research.

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1. Introduction

Let be the categories (Verdier, 1996) [1], (Keller *et al.*, 1996) and (Yekutieli, 2019) [6], (whose points are sets of propositions) $\Phi_1, \Phi_2, \ldots, \Phi_n, \ldots,$ of an Abelian category [1] $\mathcal{R}$. These sets can be set of propositions of certain class $\alpha,$ then these can to define the following category $\mathfrak{T}\Phi_\alpha$, whose objects are sets with arrows and therefore sequences as:

$$\Phi_0 \overset{d_0}{\to} \Phi_1 \overset{d_1}{\to} \Phi_2 \overset{d_2}{\to} \Phi_3 \to \ldots$$

which defines the research process starting of the category of true propositions belonging to a class of the knowledge in mathematics and physics $EFISMAT$, such and as is given in the method by fundaments (Bulnes, 2010), (Method by Fundaments, Bulnes., 2025). Also, here each Φ_i, is an object of $\mathscr{R}$, and each compositions $d^i \circ d^{i+1}$, is zero. The ith −cohomology group of the complex is $H^i(\Phi_i) =$
$\ker d^i / \operatorname{im} d^{i-1}$.
If in particular the categories of objects I, $EFISMAT$, $Th\Sigma$, $\mathfrak{T}\Phi\alpha$, $\{\pi j\}$, π^*, P, and 0, defined in (Verdier, 1996) [1], (Keller *et al.*, 1996), (Yekutieli, 2019) [6], (Bulnes, 2010), and (Method by Funsdaments, Bulnes., 2025), we have the research method by fundaments diagram

[1] This can be a modules category on a ring, or category of sheaves of Abelian groups on a topological space, for example topological groups.

$$\begin{array}{c} \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \mathcal{P} \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \downarrow \\ I \to E_{FISMAT} \to \Phi_\alpha \to \mathfrak{T}\Phi_\alpha \to Th\Sigma \to \{\pi_j\} \to \pi * \to P \to 0, \\ (1) \\ \downarrow \qquad\qquad\qquad \downarrow \\ subTh\Sigma \qquad\qquad Pat \end{array}$$

which is totally reversible generating isomorphism between categories (Method by Fundaments, Bulnes., 2025). The diagram (1) is an exact sequence in cohomology (Method by Fundaments, Bulnes., 2025), (Harmony and Precision, Bulnes., 2025) and (Recurrent Cycles, Bulnes., 2025), and has been studied with much detail and careful in (Mazza *et al*., 2006).

2. The specific problem in the applied research

The applied research requires iterative cycles to obtain a refinement of a technology or technological product, which goes perfecting its quality (efficiency, accuracy, functionality, and etcetera).

Now, when those cycles run out? From a point of view of the commutative rings that compose the research method by fundaments, this is risked when is achieves a Spectrum [2] of the ring isomorphic to the integer set. This on products of research, for example, number of prototypes, number of PhD dissertations, number of results, and even number of technologies as completed products.

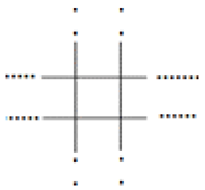
Here is useful the functor Spec, in the diagram of research method by fundamentals. Likewise,

$$\text{Spec: CRing} \longrightarrow \text{AffSch}, \qquad (2)$$

We consider an immediate consequence of the first theorem of consistance [4, 6] of the mathematical research theory given by the general scheme and its cuadricle:

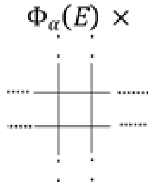
$$\Phi_\alpha(E) \times \Pi$$

$$\sim \quad \begin{array}{ccc} \Gamma_i \ G \ \Phi_\alpha(E) \times \Pi & \to & \Pi \\ \downarrow & & \downarrow \\ \Gamma_0 \ G \ \Phi_\alpha(E) & \to & Hom\ (\kappa,\, t_\sigma) \end{array} \qquad (3)$$



Then in the applied research [3], the cyclicity of the research method by fundaments (Recurrent Cycles, Bulnes., 2025), is applied to its correponding commutative diagram the diagram having the equivalence[4]

$$\Phi_\alpha(E) \times$$



$$\sim \quad \begin{array}{ccccc} Th_{app} & \to & \{\pi_j\} & \to & \pi * \\ \downarrow & & \downarrow & & \downarrow \\ \{\pi_j\} & \to & \pi * & \to & P \\ \downarrow & & \downarrow & & \downarrow \\ \pi * & \to & P & \to & 0 \end{array} \qquad (4)$$

where we remember that there are subschemes given in the method scheme, for example to the $SubTh\Sigma \cong ThApp$, generating certain loops or cycles, for example given by (4). Likewise, $\Phi\alpha(E) \times 0\mathfrak{T}$, is the cuadricle (which can extend it infinitely) of the correspondences, $0\mathfrak{T}$, is the category of the functors ($P \longrightarrow 0$). Likewise, two cycles that we can call Γ_0, and Γi (i = 1, 2, □, n) satisfy (Mazza *et al*., 2006)

Could be used the Spec functor in the mathematical research theory?

Yes, the Spec functor is a central concept in mathematical research, particularly in algebraic geometry, where it is a contravariant functor that maps a commutative ring to its affine scheme (a topological space). It is crucial for translating algebraic properties of rings into geometric properties of spaces, allowing mathematicians to use geometric intuition to solve algebraic problems and to study the geometry of rings.

We can consider the applied research as a theory that is completely consignated in engineering when is directly

$$\begin{array}{ccc} \Gamma_i \ G \ \ Th_{app} \times 0_{\mathfrak{T}} & \to & \{\pi_j\} \\ \downarrow & & \downarrow \\ \Gamma_0 \ G \ 0_{\mathfrak{T}} & \to & \pi^* \end{array} \qquad (5)$$

where $0_{\mathfrak{T}}$, is the category of the solutions obtained from the sequence

$$\ldots \to \{\pi_j\} \to \pi^* \to P \to 0$$
$$\ldots \nearrow \qquad (6)$$

From (5) is clear that the relation

$$Th_{app} \times 0_{\mathfrak{T}} \to 0_{\mathfrak{T}}, \qquad (7)$$

is only a projection. The relation more complicated is given when

$$\{\pi_j\} \times 0_{\mathfrak{T}} \to \pi^*, \qquad (8)$$

Likewise, said relation is not projection. However, we can consider a cycle to obtain π^*, from $\{\pi j\} \times 0\mathfrak{T}$. For example, if we consider $Thapp \cong \pi^*$, its realization as technology

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[2] Could be used the Spec functor in the mathematical research theory?
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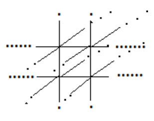
[3] We can consider the applied research as a theory that is completely consignated in engineering when is directly functored to the category $\{\pi j\}$, as is viewed in the fundamental sequence in the research method by fundaments.

[4] Of fact, these diagrams can be extended with depth (forward and backward):



under research is given by of the integral (Recurrent Cycles, Bulnes., 2025), (Bulnes, 2013) and (Thrift and Musk, 2019) [2]

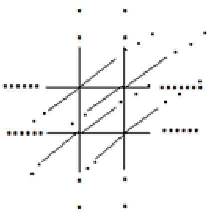
$$\int_{z} \phi^2(\pi^*)\, \mu_\chi = \xi\|\phi\|_2, \qquad \forall\xi > 0 \qquad (9)$$

could be demonstrated that in a engineering technology research exist a set of integer multiple parameters that must satisfied?

In engineering and technology research, it is common to find sets of parameters that must be integer multiples of a base value. These constraints arise from the physical nature of components, manufacturing requirements, discrete control systems, or mathematical optimization models, for example the functors class $\{\pi j\} \longrightarrow \pi^*$. Likewise, a concrete example exists in the fundamental frequency and harmonics in electronics. However, this is not a rule.

However, in the research context refers to the unit number of research products, for example, number of prototypes, number of theoretical results, or even number of research units, or experiments. These ítems never are of fractional nature.

Likewise, if is had certain research in engineering in process (Bulnes, 2013) and (Thrift and Musk, 2019) [2], by the scheme of research by fundaments (Bulnes, 2010), (Method by Fundaments, Bulnes., 2025) (Harmony and Precision, functored to the category $\{\pi j\}$, as is viewed in the fundamental sequence in the research method by fundaments. Of fact, these diagrams can be extended with depth (forward and backward):



Bulnes., 2025) and (Demaine *et al*., 2018) [3], we have in general

$$\begin{array}{ccccccccc} \ldots \to A \to B \to & C - - - \to & D \to P \to 0 & & \\ & \swarrow \downarrow & \swarrow \downarrow & & \\ & \to Th_{app} \to \mathrm{Spec}_1 \to \mathrm{Spec}_2 & & & \end{array} \qquad (10)$$

where the two contiguous cycles establish a commutative diagram, as example in the order of the engineering research:

$$\begin{array}{c} Th_{app} \to \{\pi_j\} \to \pi^* \to P \to 0 \\ \downarrow\ G \downarrow G\ \downarrow \qquad \nearrow \\ \{\pi_j\} \to \pi^* \to P \end{array} \qquad (11)$$

Then a prototype πj, is a spectum of $Thapp$. Then through a research prototype πj, and under certain transformations and optimization conditions (eficciency, efficacy, effectiveness) is obtained π^*. Then, if we want this to be a product $P \longrightarrow 0$, we have that realize transformations in π^*, for its sale as final product that will solve a social necesity. Said products always are in discrete unit, therefore isomorphic to $\mathbb{Z}$.

Def. 2.1. Remember that an engineering reseach is in a $Thapp$, (which also satisfies proposition A. 1). Then all product from $Thapp$, is a prototype of $\{\pi j\}$, which is a technology on the energy. Then satisfies (9) [5] which is a realization on a Hilbert space.

Def. 2. 2. Considering a sequence of categories, $\ldots \to A_i \to A_{i+1} \to \ldots$, a subscheme[6] from A_i, isomorphic to a cycle is the diagram

$$\begin{array}{ccc} A_i & \to & A_{i+1} \\ \downarrow & & \downarrow \\ A_{i+1} & \to & A_{i+2} \end{array} \qquad (12)$$

(which is justified by the first consistence theorem of the mathematical theory of the research (Method by Fundaments, Bulnes., 2025)). There is a cycle group.

Remember that the Spec functor Spec, goes from the category of commutative rings CRing, to the category of affine schemes AffSch, is to say, Spec: CRing → AffSch. Then an affine subcheme is a mathematical object representing a commutative ring as a geometric space, constructed as a locally ringed space that is isomorphic to the spectrum of that ring.

Def. 2.3. An affine scheme is a mathematical object representing a commutative ring as a geometric space, constructed as a locally ringed space that is isomorphic to the spectrum of that ring. This "spectrum" is the topological space of prime ideals of the ring, equipped with a "structure sheaf" that assigns local rings to open sets. Affine schemes generalize affine varieties, and a general scheme is a space that can be covered by affine schemes.

3. Mean result

Theorem 3.1. We consider in a applied research process of the research method by fundaments that:

$$\begin{array}{c} \ldots \to A \to B \to C \to D \to E \to P \to 0 \\ \searrow \downarrow \Gamma_i \downarrow \Gamma_0 \searrow \downarrow \qquad \nearrow \\ Th_{app} \to D \to \mathrm{Spec}\mathbb{Z} \end{array} \qquad (13)$$

where Γi, is a cycle. Then exists a unique affine subscheme E, given by $SubTh \cong \Gamma 0$, of ΓE, whose $E \cong \mathrm{Spec}\,\mathbb{Z}$.

Proof: Indeed, the ring of integers Spec$\mathbb{Z}$, is a domain of principal ideals, which implies that the category of its modules has a particular structure. The spectrum of the ring is its set of prime ideals, which for Spec$\mathbb{Z}$, is the set of primes and the zero ideal (the spectrum is usually considered as the affine variety Spec$\mathbb{Z}$. This implies that there is a single affine subscheme (a principal prime ideal $\mathbb{Z}$) which corresponds to

[5] Now its realization as technology under research (for case of a prototype) is getting through the integral (9) (Recurrent Cycles, Bulnes., 2025).

[6] A closed subscheme is a fundamental concept in algebraic geometry that refines the notion of a closed subset of a scheme by including a specific "scheme structure" (defined by a sheaf of ideals).

the spectrum isomorphic to the set of integers, which is given by the zero ideal. Likewise, the initial cycle of the commutative diagram of the research method that is isomorphic to a subtheory is such an affine subscheme, since it refers to the structure of the category of modules (or, more specifically, of homomorphisms, remember the homomorphisms ($\{A\}$), that satisfies the integrals in a cycle Γ, in the research method by fundaments $\oint \Gamma = 0$, (Recurrent Cycles, Bulnes., 2025), where we have applied the Def. 2. 1, Def. 2. 2, and proposition A.1). Indeed, we consider the property of the line integrals on $\Gamma E = \Gamma 1 \cup \Gamma 2 \cup \Gamma 0$, and apply the integration of adjunt cycles considering the diagram (13) of the category's context of the research method by fundaments with the adequate orientation. Also apply the first theorem of consistance (Harmony and Precision, Bulnes., 2025), (Recurrent Cycles, Bulnes., 2025). of the mathematical theory of the reseach:

$$\begin{array}{c} \ldots \to \mathfrak{T}\Phi_\alpha \to Th_{App} \to \{\pi_j\} \to \pi^* \to P \to 0 \\ \searrow \uparrow \ \partial\ \Gamma_1 \ \uparrow \partial\, \Gamma_2 \uparrow \partial\, \Gamma_0 \uparrow \ \nearrow \\ Th\Sigma \to Th_{App} \to \{\pi_j\} \to \pi^* \end{array} \quad (14)$$

Then the integral on the cycles satisfies (Recurrent Cycles, Bulnes., 2025), (Cohomology of Cycles, Bulnes., 2008), (Watanabe, 2008, 2009) [5], and (Yekutieli, 2019) [6]:

[6] A closed subscheme is a fundamental concept in algebraic geometry that refines the notion of a closed subset of a scheme by including a specific "scheme structure" (defined by a sheaf of ideals).

$$\oint \Gamma_E = \int_{\Gamma_1 \cup \Gamma_2 \cup \Gamma_0} \phi(Th_{App})\phi(\{\pi_j\}) - \phi(\pi *)\phi(\{\pi j\})$$

$$= \int_{\Gamma_1} \phi(Th\Sigma)\phi(Th_{App}) - \phi(Th_{App})\phi(Th\Sigma)$$

$$+ \int_{\Gamma_2} \phi(Th_{App})\phi(\{\pi_j\})$$

$$- \phi(\{\pi_j\})\phi(Th_{App}) + \int_{\Gamma_0} \phi(\{\pi_j\})\phi(\pi^*)$$

$$- \phi(\pi^*)\phi(\{\pi_j\}) = 0, \ (15)$$

which has values in the category $0\mathfrak{T} \cong \mathrm{Spec}\mathbb{Z}$, [7] which is the prime ideal no vanish which generates a affine subscheme. The key point is that for the ring of integers $\mathrm{Spec}\mathbb{Z}$, the zero ideal is the only non-zero prime ideal and generates a unique affine subscheme that is isomorphic to the set of integers.

Remark: Remember that the cycles represent refinaments of research giving integer products. The diagram (14) is an application of the second consistence theorem of the research theory (Harmony and Precision, Bulnes., 2025), (Gelfand, 2003).

4. Applications

Some illustrative examples on the applications of the theorem are the following.

Def. 4.1. (Prototype Design). The phrase "spectrum that design the prototype or technology" implies the mathematical framework is being used as a model for an engineered system (e.g., a quantum device or a system with specific resonant properties) which in a context of the research method by fundaments is identified by π^*.

Proposition 4.1. For $\{\lambda 1, \lambda 2, \ldots, \lambda j\}$, (Simon and Reed, 1972) [7] that are the spectrum that design the prototype or technology. The spectrum degenerates in a harmonics set if the operator $A \in \mathrm{Sym}(H)$, is such that $\forall\ \psi \in H$ (with H, a Hilbert space) is had that $A\psi = \lambda\psi$, and $\mathrm{Spec}\mathfrak{T}\Phi_\alpha \cong \mathbb{Z}(k)$.
Proof. The set of eigenvalues $\{\lambda 1, \lambda 2, \ldots, \lambda j\}$, is an ordered set which is related to the cyclic group of order k, which implies periodically or specific discrete values. Then the set degenerates in harmonics set, which means that the set of eigenvalues typically represents energy levels then the spectrum of some operator $A \in \mathrm{Sym}(H)$, is isomorphic to the set that relates to a topological invariant or symmetry constraint that establish the spectrum type defined by [7] In the category of schemes, **Spec**$\mathbb{Z}$, is a terminal object (also known as a final object or a universal base). This means that for any other scheme E, there is a unique morphism (map) from E, to **Spec**$\mathbb{Z}$. Here the unique morphism from E, to $\mathrm{Spec}\mathbb{Z}$, is an isomorphism if and only if the scheme E, is affine, which by hypothesis is affine, then E, is isomorphic $\mathrm{Spec}\mathfrak{T}\Phi\alpha$, to the investigated system. Due that the cyclic group of order k, is the set $\mathbb{Z}(k)$, then $\mathrm{Spec}\mathfrak{T}\Phi\alpha \cong \mathbb{Z}(k)$.

Example 4.1. Super-integrable quantum systems often hide “accidental degeneracy” due to hidden symmetries, which leads to highly degenerate spectra.

Example 4.2. In electronics research the set of eigenvalues $\{\lambda 1, \lambda 2, \ldots, \lambda j\}$, is an ordered set which is related to the cyclic group of order k, which implies periodically or specific discrete values called harmonics of a fundamental frequency (Bulnes, 1998) [9].
Remark. The second example can be extended a non-cyclic group like $\mathbb{Q}(k)$.

5. Conclusions

The property of the commutative scheme of derived categories of the research method by fundaments diagram establishes subtheories $SubTh$, whose cycle is such affine subscheme, since it refers to the structure of the category of modules (or, more specifically, of homomorphisms, which by recurrent cycles satisfies the integral (15). Then this has values in the category $0\mathfrak{T} \cong \mathrm{Spec}\mathbb{Z}$, which is the prime ideal no vanish which generates the affine subscheme mentioned. The key point is that for the ring of integers $\mathrm{Spec}\mathbb{Z}$, the zero ideal is the only non-zero prime ideal and generates a unique affine subscheme that is isomorphic to the set of integers.

[7] In the category of schemes, **Spec**$\mathbb{Z}$, is a terminal object (also known as a final object or a universal base). This means that for any other scheme E, there is a unique morphism (map) from E, to **Spec**$\mathbb{Z}$. Here the unique morphism from E, to $\mathrm{Spec}\mathbb{Z}$, is an isomorphism if and only if the scheme E, is affine, which by hypothesis is affine, then E, is isomorphic to $\mathrm{Spec}\mathbb{Z}$. Remember that the unique morphism is a map from a scheme to the spectrum of its global sections, which is an isomorphism only in the specific case where the scheme is affine.

Likewise, is had the solution P → 0, that finally gives solution to one society necessity. Finally, this has that see with the design of a prototype in π^*, which is the best prototype to be a product P → 0. In electronics and quantum field theory research this means that the harmonics set $\mathfrak{T}\Phi_\alpha$, derived from the proper research, its spectrum of some operator $A \in \mathrm{Sym}(H)$, is isomorphic to the set that relates to a topological invariant or symmetry constraint that establish the spectrum type and due to that the cyclic group of order k, is the set $\mathbb{Z}(k)$, then $\mathrm{Spec}\mathfrak{T}\Phi_\alpha \cong \mathbb{Z}(k)$, which is an immediate corollary of the theorem 3.1.

Appendix A. Basic Definitions and Relations

Def. A.1. A technologiscism is a neologism that obtains a technology from a technology given. Likewise, $\phi_U(t\gamma) = t\delta$.

Def. A.2. A prototype π, is a technology under research (non- finished product). The theory that generates is a sub-theory or the category $subth\Phi$. An optimal prototype $\pi*$, is a technology ready to be product P.

Proposition A.1. [6, 7]**:** An applied theory is a sub-theory, therefore $SubTh\Phi \cong Thapp$.

All research unit $Cn\Phi_\alpha$, is defined as the place (space) where only exist true propositions. Then a theory based on models of true propositions sets is the category of morphisms given to $\mathrm{Spec}\mathbb{Z}$. Remember that the unique morphism is a map from a scheme to the spectrum of its global sections, which is an isomorphism only in the specific case where the scheme is affine. by Hom $(Th\mathrm{Mod}\Phi_\alpha\ (E_{FISMAT}),\ Cn\Phi_\alpha)$ is isomorphic to the set of morphisms (creation of technologies) $Hom\ (\phi_\sigma(t_\gamma),\ t_\eta)$.

Def. A.3. The space $\Lambda_{SYSTEM}(\Phi_\alpha(E), t_\delta)$, defines the set of technology transferences of the class τ, to the class σ, formally:

$$\Lambda_{SYSTEM}(\Phi_\alpha(E), t_\delta) = \{\tau | \tau \Longrightarrow \sigma\}, \quad (A.1)$$

Def. A.4. The category $Cn\Phi$**,** is the set of tautological applications of the true proposition category Φ, is to say

$$Cn\Phi = \{\sigma |\ \Phi \vDash \sigma\}, \quad (A.2)$$

This category is called research unit.

Technical notation.

E_{FISMAT} – Derived category of all knowledge in mathematics and physics. Locally is a Banach space [15], for example in the technology applications.

Π – Set of prototypes. This set is a derived category whose morphisms are $\{\pi_j\} \to \pi^*$.

$_\alpha$ –Scientifical technologiscism or simply technologiscism. This is a homomorphism on the the group of technologies, that is to say, $\forall\ t_\gamma$, and $t_\delta \in G\ (\circ)$, $\phi_\alpha\ (t_\gamma \circ t_\delta) = \phi_\alpha(t_\gamma) \cdot \phi_\alpha(t_\delta)$, where the image $\phi_\alpha\ (t_\gamma \circ t_\delta) \in G$.

t_α –Technology. Are the points belonging to the group G.

$\Phi_\alpha(E)$ –Set of true propositions (useful propositions) in the creation of a theory. This is a sub-category such that $\Phi_\alpha(E) \subset E_{FISMAT}$. Locally also can be a Banach space.

κ_α –The class α. This sub-category belongs to a partition of the groups G.

Λ_{SYSTEM} –Derived category of systems of utilities, manufactures and tools. Locally also is a Banach space.

Hom (A, B) –Space of homomorphism from the set A. until set B. In a commutative or noncommutative ring is a derived category of functors Hom.

$Th\mathrm{Mod}\Phi_\alpha$ –Derived category of all the statements that are true in all models of $\Phi_\alpha(E)$.

→ –Morphism.

$Th\Sigma$ – Derived category of all theories on the set of demonstrated and verified proposition in the specific research. This category is the most important in the research method by fundaments.

$Cn\Phi$ – Derived sub-category of all consequences by the research realized as final products.

≅ –Isomorphism (structural equivalence between categories, rings, groups, any sets of elements). Another similar notation in the diagrams and schemes is ⇅. Also, Isom, in the context of a derived category of functors Hom. AffSch –Category of the affine schemes.

∂ –Loops

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