THE USE OF MODERN TEACHING METHODS IN THE PROCESS OF SELF-STUDY

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Annotation. In this state, a brief recommendation is given for strengthening theoretical knowledge by the «Project» method during self study of the topic «Open (-open) action and hyperspace functor». The purpose of applying the subject to the «project» method is to teach students to think for themselves, to fully express their thoughts and opinions.
Keywords: independent work, "projects" method, open action, mappings, functor

ИСПОЛЬЗОВАНИЕ СОВРЕМЕННЫХ МЕТОДОВ ОБУЧЕНИЯ В ПРОЦЕССЕ САМООБУЧЕНИЯ

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Аннотация. В данной статье дана краткая рекомендация по укреплению теоретических знаний методом «Проект» при самостоятельном изучении темы «Открытое (-открытое) действие и функтор гиперпространства». Цель применения темы к методу «проект» - научить учащихся самостоятельно мыслить, полно излагать свои мысли и мнения.
Ключевые слова: самостоятельной работа, метод "проектов", открытое действие, отображения, функтор

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Annotatsiya. Ushbu maqolada "Open (-open) action and functor of hyperspace" мавзуни мустақил ўрганишда "Лойиҳа" методи орқали назарий билимларини мустаҳкамлаш учун қисқача тавсия берилди. Mavzuni "loyiha" metodiga qo'llashdan maqsad o'quvchilarni mustaqil fikrlashga, o'z fikr va mulohazalarini to'liq ifodalashga o'rgatishdir.
Kalit so'zlar: Mustaqil ish, "loyiha" metodi, ochiq harakat, akslantirish, funktor

Today, modern teaching methods are widely used in the process of self-study in all higher educational institutions. The use of modern methods leads to high efficiency in the process of self learning. When choosing teaching methods, it is advisable to proceed from the didactic task of each lesson.

While maintaining the traditional form of the lesson, enriching it with techniques that activate the activities of various students will lead to an increase in the level of students' mastery. To do this, the lesson process should be organized rationally, the teacher should increase the interest of students and encourage their activity in the learning process, divide the learning material into small parts, conduct brainstorming, work in small groups, discussion, problem situation. as text, projects, role-playing games and encourage students to independently complete practical exercises.

A brief recommendation is given for strengthening theoretical knowledge by the «Project» method during self study of the topic «Open (-open) action and hyperspace functor».

The «Project» method is an individual or group work of students to collect information, conduct research, and implement work on a specific topic within a given period of time. In this method, students participate in the processes of planning, decision-making, implementation, verification and conclusion, and evaluation of results. Project development can be individual or group, but each project is an agreed result of the joint activity of the study group. In this process, the student's task is to develop a new product or find a solution to another problem within a given time. From the students' point of view, the task should be challenging, and it should be a task that requires students to apply what they already know to other situations.

The project should serve learning, put theoretical knowledge into practice, and create the possibility of self planning, organization and implementation by learners. The purpose of applying the subject to the «project» method is to teach students to think for themselves, to fully express their thoughts and opinions.

Let (G,X,α) be a topological transformations group. For a space X and a group G we put

$$\exp(G,X)=\{\Phi\in \mathrm{Homeo}(\exp X): \text{there exists } g\in G \text{ such that } \Phi|_X=g\}. \tag{1}$$

Remark 2. For a correct understanding of the definition (1), note that X on formula $\Phi|_X$ must be understood as $X\cong\{\{x\}:x\in X\}$.

Clearly, for the space X, a set $\exp(G,X)$ is a group with respect to the operation of composition of homeomorphisms, and $\exp\alpha_e=\exp\mathrm{id}_X\equiv \mathrm{id}_{\exp X}$ is the neutral element of the group $\exp(G,X)$.[1:.12]

Lemma 2. For every $F\in\exp X$ and an arbitrary $g\in G$ we have

$$F\in\langle U_1,\dots,U_n\rangle \quad\Leftrightarrow\quad (\exp g)(F)\in\langle g(U_1),\dots,g(U_n)\rangle. \tag{2}$$

Proof follows from the equality $(\exp g)(F)=g(F)$, which holds for every $F\in\exp X$.

Since every $\Phi\in\exp(G,X)$ is a homeomorphism, then the statement of the Lemma 2 can be reformulated for each $\Phi\in\exp(G,X)$. Take arbitrary open set $\langle U_1,\dots,U_n\rangle\subset\exp X$. Then for every $\Phi\in\exp(G,X)$ and $F\in\exp X$ we have

$$\Phi(F)\in\langle g(U_1),\dots,g(U_n)\rangle\Leftrightarrow F\in\langle U_1,\dots,U_n\rangle, \tag{3}$$

where $g=\Phi|_X$. It is clear that the equivalence of (3) generalizes (2).

For a family $\{\gamma\}$ of open coverings of the hyperspace $\exp X$ we define a set

$$O_\gamma=\left\{\Phi\in\exp(G,X):\forall F\in\exp X,\exists W\in\gamma,\Phi(F)\in W\Leftrightarrow F\in W\right\}.$$

We put $\mathrm{N}\,(\mathrm{E})=\mathrm{N}_{\exp(G,X)}(\mathrm{id}_{\exp X})=\left\{O_\gamma:\gamma-\text{open cover of hyperspace } \exp X\right\}.$

We need the following statement, the proof of which consists of direct verification.

Lemma 3. The family $\mathrm{N}\,(\mathrm{E})$ is form a system of neighborhoods of the neutral element $\mathrm{E}=\mathrm{id}_{\exp X}$ on $\exp(G,X)$.[2: 35]

Let $\mathrm{N}\,(\Phi)=\{O_\gamma\Phi:O_\gamma\in\mathrm{N}\,(\mathrm{E})\},\qquad \Phi\in\exp(G,X),$ where

$$O_\gamma\Phi=\{\Psi\in\exp(G,X):\forall F\in\exp X,\exists W\in\gamma,\Psi(F)\in W\Leftrightarrow\Phi(F)\in W\}.$$

Thus, $\exp(G,X)$ getting topological group. Therefore, for α we can define an action $\exp(\alpha):\exp(G,X)\times\exp X\to\exp X$ according to the rule.

$(\exp\alpha)(\Phi,F)=\Phi(F),\qquad (\Phi,F)\in\exp(G,X)\times\exp X.$ In particular, for pairs of the form $(\exp g,F)\in\exp(G,X)\times\exp X$, where $g\in G\subset\mathrm{Homeo}(X)$, we have

$$(\exp\alpha)(\exp g,F)=(\exp g)(F)=g(F),\qquad F\in\exp X. \tag{4}$$

From (3) the following important equality follows

$$\Phi(\langle U_1,\dots,U_n\rangle)=\{\Phi(F):F\in\langle U_1,\dots,U_n\rangle\}=\langle g(U_1),\dots,g(U_n)\rangle \tag{5}$$

for open sets $\langle U_1,\dots,U_n\rangle\subset\exp X$, elements $\Phi\in\exp(G,X)$, and closed sets $F\in\exp X$ and $g=\Phi|_X$.

Let now O_γ be an open neighbourhood of the neutral element E. Then from (4}) and (5}) follows that

$$(\exp\alpha)(O_\gamma,\langle U_1,\dots,U_n\rangle)=\bigcup_{\Phi\in O_\gamma}\langle\Phi|_X(U_1),\dots,\Phi|_X(U_n)\rangle. \tag{6}$$

Thus, we have proved the following statement, the proof of which is extracted from (6).

Proposition 1. For arbitrary open action $\alpha : G \times X \to X$ the map $\exp\alpha : \exp(G,X) \times \exp X \to \exp X$ is open.

Now we prove the openness of the action $\exp\alpha$ under additional conditions.

Proposition 2. For arbitrary open action $\alpha : G \times X \to X$ and every positive integer n the action

$$\exp\alpha : \exp(G,X) \times \exp_{nn} X \to \exp_{nn} X \qquad (7)$$

is open.

Proof. Clearly, $|\Phi(F)| = |F| = n,$ for every $F \in \exp_{nn} X$ and for all $\Phi \in \exp(G,X)$. Therefore, the map (7) is defined correctly.

On other side, for every $F \in \exp_{nn} X$ and arbitrary $O_\gamma \in \mathrm{N}\ (\mathrm{E})$ we have

$$O_\gamma F = \{\Phi(F) : \Phi \in O_\gamma\} = (\exp_{nn} X) \cap \left(\bigcup_{F \in W \in \gamma} W \right).$$

But then $F \in \operatorname{int}_{\exp_{nn} X}(O_\gamma F)$. Proposition 2 is proved.

Openness of an action $\alpha : G \times X \to X$ at Preposition 2 is important.

Example 1. Consider a space (D, τ_D), in which all single-point sets are closed, and there are n points we say that $d_1, \ldots, d_n \in D$, for which the set $\{d_i\}$ is not open, $i = 1, \ldots, n$. Consider a group $G_{\{d_1,\ldots,d_n\}} = \{g \in \mathrm{Homeo}(D) : g(d_i) = d_j, \quad i,j = 1,\ldots,n\}$

with the operation of composition of mappings. Let $\mathcal{A} = \{\gamma\}$ be a family of open coverings of D. In the set $G_{\{d_1,\ldots,d_n\}}$ a topology is introduced using neighborhood systems:

$$O_\gamma(g) = \{h \in G_{\{d_1,\ldots,d_n\}} : \forall x \in D, \exists U \in \gamma, g(x) \in U \wedge h(x) \in U\}, \qquad g \in G_{\{d_1,\ldots,d_n\}}.$$

Thus, $G_{\{d_1,\ldots,d_n\}}$ is a topological group. Note that an action $\alpha : G_{\{d_1,\ldots,d_n\}} \times D \to D$ is not open. Indeed, for an arbitrary open neighborhood O of the neutral element $\mathrm{e} = \mathrm{id}_D$ and points $d_i \in D$ a set $Od_i = \{g(d_i) : g \in O\} = \{d_j\}$

is closed, but is not open. Then $\operatorname{int}(Od_i) = \varnothing$ and $d_i \notin \operatorname{int}(Od_i)$, $i,j = 1,\ldots,n$.

Now we show that the action $\exp\alpha : \exp(G_{\{d_1,\ldots,d_n\}}, D) \times \exp_{nn} D \to \exp_{nn} D$ also is not open. Actually, for each neighborhoods O of the neutral element $\mathrm{id}_{\exp D}$ a set

$$O\{d_1,\ldots,d_n\} = \{\Phi(\{d_1,\ldots,d_n\}) : \Phi \in O\} = \{\{d_1,\ldots,d_n\}\}$$

is closed in $\exp D$, but is not open in it. Then $\{d_1,\ldots,d_n\} \notin \operatorname{int}(O\{d_1,\ldots,d_n\}) = \varnothing$.

For case (weakly) d-open action has the following strengthened variant of Proposition 2.

Proposition 3. For each d-open action $\alpha : G \times X \to X$ and every positive integer n the action $\exp\alpha : \exp(G,X) \times \exp_n X \to \exp_n X$ is d-open.

Proof. From the Lemma 1 follows that $[W \cap (\exp_{nn} X)]_{\exp X} = [W \cap (\exp_n X)]_{\exp X}$. for every open set W in $\exp X$. Hence,

$$\operatorname{int}_{\exp_n X}\left([W \cap (\exp_{nn} X)]_{\exp X} \right) = W \cap (\exp_n X).$$

Therefore, for each $F \in \exp_n X$ and arbitrary $O_\gamma \in \mathrm{N}\ (\mathrm{E})$ we get

$$F \in \operatorname{int}_{\exp_n X}\left(\left[O_\gamma F \right]_{\exp X} \right).$$

Proposition 3 is proved.

Proposition 4. For any weakly d-open action $\alpha : G \times X \to X$ and each positive integer n the action $\exp\alpha : \exp(G,X) \times \exp_n X \to \exp_n X$ is weakly d-open.

Proof the proof consists of a small modification of the proof of Proposition 3.

For the action $\exp\alpha : \exp(G,X)\times\exp_{nn} X \to \exp_{nn} X$ and the set $F\in\exp_{nn} X$ we define a map $(\exp\alpha)_F : \exp(G,X)\to\exp_{nn} X$ in a standard way, i.e.

$$(\exp\alpha)_F(\Phi)=\Phi(F), \qquad \Phi\in\exp(G,X).$$

Proposition 5.

For any n openness (d-openness) of continuous action (7) is equivalent to openness (d-openness) of the map $(\exp\alpha)_F$, $F\in\exp_{nn} X$.

Proof. Let the action $\exp\alpha$ be open, $\mu\in\exp X$, a set O is open in $\exp(G,X)$. For any $\Phi\in O$ we have $O\Phi^{-1}\Phi(F)=OF$ and $O\Phi^{-1}\in \mathrm{N}\ (\mathrm{E})$. Thus $\Phi(F)\in\mathrm{int}(O\Phi^{-1}\Phi(F))=\mathrm{int}(OF)$ and consequently, $(\exp\alpha)_F(O)\subset\mathrm{int}((\exp\alpha)_F(O))$.

If the map $(\exp\alpha)_F$ is open, then $(\exp\alpha)_F(O)=\mathrm{int}((\exp\alpha)_F(O))$ holds for arbitrary $O\in\mathrm{N}\ (\mathrm{E})$. Therefore $\mu\in\mathrm{int}(OF)$.

The d-openness case is established by the same way.

Proposition 6. The action $\exp\alpha$ on $\exp_n X$ is d-open if and only if for for any $O\in\mathrm{N}\ (\mathrm{E})$ and $F\in\exp X$ there exists neighbourhood V of F in $\exp_n X$ such that $V\subset\{\Phi W:\Phi\in O\}$ for arbitrary nonempty open in $\exp_n X$ subset $W\subset V$.

Proof. Clearly, the action is d-open at F, if for each $O\in\mathrm{N}\ (\mathrm{E})$ there exists neighbourhood V of the set F in $\exp_n X$ such that for every nonempty open set on $\exp_n X$ subsets $W\subset V$ exists $\Phi\in O$, for which $F\in\Phi W$ (see. [7: 56], remark 4).

Proposition 1 and Lemma 3 [7: 67] imply necessity.

Proposition 7. For an open (a d-open) map $f:X\to Y$ the map $\exp f:\exp X\to\exp Y$ also open (d-open).

Proof. It is enough to show that

$$(\exp f)(\langle U_1,\dots,U_k\rangle)\subset\mathrm{int}\big((\exp f)(\langle U_1,\dots,U_k\rangle)\big).$$

But, this follows from the fact that the functor $\exp$ preserve the openness of maps [9: 107].

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