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IMPROVEMENT QUALITY OF PREPARATION SPECIALISTS IN AREA OF MATHEMATICAL MODELING

Abstract. Improvement quality of preparation specialists in area of mathematical modeling is an actual problem in education students (especially applied) and non mathematical specialties. For solving this problem must be used system and successive exposition of maintenance of the stages of building model with obligatory demonstration of there intercommunications. Each stage of modeling makes some part of quality of model. Most difficult stage is idealization of original, because in this case the most important properties of original must be distinguished and the experimental samples of output of variables of original and calculation samples of model are got.. Main attention it must be spared to estimation of adequacy original and model with the help of famous nonparametric criteria such as criterion Wilcoxon and special criterion for small samples. Last part of modeling usually is optimization parameters of original.
Methodology of study, that provides a receipt of the deeper and complete understanding of essence of mathematical modeling of technical objects is offered. Positive results are achieved by using method which is proposed.
System exposition of material and accent on research and proof adequacy of model allow to attain the deeper and complete understanding of essence of mathematical design of technical objects and promote efficiency of preparation of specialists in area of the applied mathematical modeling.
Key words: education, design, adequacy, quality, preparation.

Introduction. Mathematical modeling is important addition, and sometimes and by an alternative (especially for expensive and unique objects), for model methods of research of the systems.

For the learning the mathematical modeling to curricula of technical (and other non mathematical) specialties are included special disciplines (in further exposition – mathematical modeling or MM), in which examined common questions of modeling (including using mathematical methods) for applied profile fields (for example, engineer, metallurgy, informative and economic systems etc.)

For successful mastering disciplines MM must be executed certain terms, which may be divided on external and internal demands according to discipline MM.

External demands mainly are taken into account in structural-logical scheme

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(which are realized in curriculum) preparation of specialist. There must be envisaged a preliminary study of providing disciplines (in particular mathematics, informatics and some profile disciplines). Thus necessary divisions and volumes of study of providing disciplines are stipulated by the requirements of qualifying description of preparation of specialist. In turn, discipline MM is providing discipline for special profile disciplines of curriculum and its structure and volume also stipulated by corresponding qualifying description.

Internal demands are stipulated mainly by didactic features of learning discipline MM. The aim of learning discipline MM is system task, namely, acquisition of skills of construction and use of mathematical models. During teaching mathematical modeling it is necessary jointly to examine maintenance, connected with strictly mathematical questions and actions, which are connected with creation models (*(actually a modeling*). The idea of the system must pierce all stages of study of disciplines MM. Exposition all that executable parts of curricula (realization of lecture, practical and other types of lessons) must provide the achievement of this aim.

For creation of mathematical model it is necessary consistently to execute the row of actions, namely, **forming the aim, idealization of original, formalization, identification and testing adequacy model.**

Forming the aim at creation of mathematical model means pointing **setting of model**, the required exactness and possible cost of modeling.

Pointing **setting of model** must include description of aim for using model (for example, for researches, managements, optimizations) and field of using (turndowns of entrance and output variables). Exactness and possible cost of modeling are associated.

Idealization of original is executed for simplification initial object by the way of reasonable exception from consideration of unimportant properties of original. Foundation for exception is quality analysis of maintenance of properties and quantitative estimation of degree of influence of entrance variables on output variables. For example, it is possible to except properties which are not mentioned in the aim of modeling. Other reason for exception may be small sizes of coefficients of pair correlation between according input and output varieties.

Formalization consists in a reasonable choice of block-hierarchical structure of mathematical model and forms of mathematical expressions for description model. Structural complication of model (quantity of submodels, their connections, number levels of hierarchies) determines by demands of accuracy of modeling and by results of idealization. Kinds of mathematical expressions for description model

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(submodels) elects by the folded traditions in concrete application field or gets out universal form of unidimensional or multidimensional polynomials.

As a result of formalization is created mathematical model for big group close in physical nature originals.

Identification is doing for excretions of model for concrete original from this group by the way of definition numbers of parameters of mathematical model. These numbers are definited on the base of aim creation model by the way of analyzing known apriori information or by special experiments and treatments of their results (for example by methods of regressive analysis).

Testing adequacy of model is doing for estimation level of conformity of mathematical model and the original, which has some difficulties in the conditions of deficit of information and limit resources of time and facilities**.**

Conformity is provided if idealization, formalization and identification are doing in correct way during building models, and accuracy input and output information (for one and some samples). If level of adequacy is not sufficient, it is necessary to analyze content works on each stages of creation model, something change and to obtain implementation of condition conformity.

Depending from brunch of using mathematical modeling there is [1] definite opinion about the level of conformity for models, which used during investigation, designing or using original. Particularly, during investigation of originals it is possible maximum level of mistake (near 20%), during designing of originals demands more strong conditions to accuracy (near 7%), and during using of originals these demands are most strong (near 3%).

The problem of an estimation of conformity (the term adequacy is sometimes used) of mathematical model and the original can be considered [4] as a version of a known problem about checking of uniformity of two samples, formed by target variables of mathematical model and the original. Let elements of two samples, which are realizations of target variables of model and the original, are mutually independent and submit to continuous distributions. The basic checking hypothesis, consists in the assumption, that both samples are taken from the same sets and, so means that functions of distribution of random variables are identical.

Considering, that in real conditions of modeling it is often inconvenient to receive the necessary information on laws of distribution of the random variables forming samples, expediently use for this purpose nonparametric criteria. Famous criteria of this type are criterion Wilcoxon and special criterion for small samples.

Let's look the specialties of application the criterion Wilcoxon:

1. At first it must be build variational raw for numbers of elements of both samples.

2. Calculate criterion Wilcoxon as sum of ranks (serial numbers) of elements of smaller sample.

3. Compare criterion Wilcoxon with it criterial values, which are depends from volumes of both samples and significance value *Q*.

4. Hypothesis about adequacyfor significance value *Q* is proved if value of criterion Wilcoxon is between minimum and maximum criterial values.

Criterion Wilcoxon provides an opportunity of the analysis small samples, including case when in one of samples is one value (the minimum quantity of values is equal the second sample 9 at a significance value of 10 %). Considering, that criterion Wilcoxon possesses, besides with sufficient power and efficiency, allows to allocate area of modeling, criterion Wilcoxon is recommended to be used as the core at estimation conformity of mathematical model and original.

More difficult is task to estimate adequateness of model when the quantity of information is too small, for example, as it may be for the metallurgical processes. In this case it is necessary to use other criteria, which is based on small samples as for model so for original. It shows what is the difference between testing variety and average value for bigger sample (for original or model) on a relation to mean quadratic deviation for this sample.

The criteria may be built in such way:

1. For bigger sample (indifferently model or origin) calculate statistical characteristics

$$\overline{\xi} - \frac{1}{n}\sum_{i=1}^{n}\xi_i,$$

$$(S^*)^2 = \frac{1}{n}\sum_{i=1}^{n}\left(\xi_i - \overline{\xi}\right)^2$$

2. Determine the value of criteria

$$\zeta\left(\overline{\xi}, S^*\right) = max\left|\left(\xi_r' - \overline{\xi}\right)/S^*\right|,\ r = \overline{1, m}.$$

3. According to rule of criteria main hypothesis (about the conformity of testing variety) is true if it is true such condition

$$\zeta\left(\overline{\xi}, S^*\right) < \zeta(n, Q)$$

where n – volume of bigger sample,

ξ_r' - testing variety.

Practical using of criteria may be more simple if take its limit values

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$$\xi_{max} = \overline{\xi} + \zeta(n, Q) \cdot S^*$$

$$\xi_{min} = \overline{\xi} - \zeta(n, Q) \cdot S^*$$

If testing variety is placed between limit values so it means that hypothesis about the conformity of testing variety is true with a definite level of significance value *Q*.

The finishing stage of decision of task of modeling of the real object usually is optimization. Depending on maintenance of concrete task [2] one (rarer a few) of output variables of mathematical model gets out as a criterion of optimization, and other output variables are taken into account in problem of optimization definition as limitations as equalities or inequalities.

Optimization is based on mathematical models (which are built) and is doing for determining optimal numbers of input varieties and parameters of model. For solving such task may be used enough universal gradient method based on application of the known [2] receptions of the extreme planning of model experiments,

System exposition of material and accent on research and proof adequacy of model allow to attain the deeper and complete understanding of essence of mathematical design of technical objects and promote efficiency of preparation of specialists in area of the applied mathematical modeling.

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Підвищення якості підготовки фахівців в галузі математичного моделювання

Підвищення якості підготовки фахівців в області математичного моделювання є актуальною проблемою в освіті студентів (особливо прикладних) та нематематичних спеціальностей.

Для рішення цієї проблеми повинне бути використано системне та послідовне представлення змісту етапів створення моделі з обов'язковою демонстрацією їх взаємозв'язків. Кожний етап моделювання створює певну частку якості моделі. Найбільш складним етапом є ідеалізація оригінала, так як в цьому випадку самі важливі якості оригіналу повинні бути визначені, и одержані експериментальні вибірки вихідних перемінних оригіналу та розрахункові вибірки моделі. Головна увага повинна бути приділена оцінці адекватності оригіналу та моделі за допомогою відомих непараметричних критеріїв таких як критерій Wilcoxon і спеціальний критерій для малих вибірок. Критерій базується на статистичному аналізі вихідних перемінних моделі та оригіналу. За необхідності розробляються нові конструктивні або технологічні пропозиції для вдосконалення оригіналу. Кінцевою частиною моделювання зазвичай є оптимізація параметрів оригіналу. Метод оптимізації обирається в залежності від виду моделі та змісту задачі.

Запропоновано методологію навчання, яка забезпечує досягнення більш глибокого та повного уявлення щодо сутті математичного моделювання технічних об'єктів. Позитивні результати отримані завдяки використанню метода, який було створено.

Системне представлення матеріалу та акцент під час навчанні на дослідженні та доведенні адекватності моделі дозволяють получити більш ясне розуміння студентами сутності математичного моделювання технічних об'єктів і підвищити ефективність підготовки фахівців в області прикладного математичного моделювання.

Improvement quality of preparation specialists in area of mathematical modeling

Improvement quality of preparation specialists in area of mathematical modeling is an actual problem in education students (especially applied) and non mathematical specialties.

For solving this problem must be used system and successive exposition of maintenance of the stages of building model with obligatory demonstration of there intercommunications. Each stage of modeling makes some part of quality of model. Most difficult stage is idealization of original, because in this case the most important properties of original must be distinguished and the experimental samples of output of variables of original and calculation samples of model are got.. Main attention it must be spared to estimation of adequacy original and model with the help of famous nonparametric criteria such as criterion Wilcoxon and special criterion for small samples. This criterion is based on the statistical analysis of output variables of the

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model and original. At a necessity new structural or technological suggestions are developed for perfection of original. Last part of modeling usually is optimization parameters of original. The method of optimization is elected depending on the type of model and maintenance of task.

Methodology of study, that provides a receipt of the deeper and complete understanding of essence of mathematical modeling of technical objects is offered. Positive results are achieved by using method which is proposed.

System exposition of material and accent during the teaching on research and proof adequacy of model allow to attain the deeper and complete understanding by students of essence of mathematical design of technical objects and promote efficiency of preparation of specialists in area of the applied mathematical modeling.

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