**COEFFICIENT OF EFFICIENCY IN PEDAGOGICAL AND SCIENTIFIC WORK OF A TEACHER AND A GROUP OF UNIVERSITY TEACHERS**

Financial resources are provided for realization of pedagogical performance (PP) and scientific performance (SP) at the university. Efficiency of its usage is subject of research for many researchers. In this paper we show practical quantification model of PP and SP of university teacher and university organizational units (i.e. groups of teachers, university department, groups of departments, faculty, groups of faculties, university). We respect recommended expenditure ratio PP : SP = 60 : 40 of provided financial resources.

**Key words:** Coefficient of Efficiency, Measurability of Pedagogical and Scientific Work, University Teacher.

1. **Introduction**

Coefficient of Efficiency \( E = \frac{\text{Input}}{\text{Output}} \) of an aggregated basic university teacher’s work performance per one academic year is studied using analytical methods and graphic instruments with regard to equilibrium \( E = 1 \). If \( E < 1 \) then the value of performance is lower than invested financial resources and it is necessary to seek the cause of such negative occurrence. If \( E > 1 \) then the proven work performance of university teacher or organisational unit should be additionally appreciated, although norms should not be increased. Expected equilibrium \( E = 1 \) might exhibit certain signs of instability if unit quality (balanced, standardized) PP (SP) for performance evaluation is set incorrectly.

2. **Measurability of the basic pedagogical performance**

Quality of university teacher’s PP per one academic year is defined by the following formula:

\[
PP = \sum_i (NSG)_i (NSC) + \sum_j (NDT)_j (NSC) + \\
+ \sum_k (NMT)_k (NSC) + \sum_l (NBT)_l (NSC) + \\
+ \sum_m (NPG)_m (NSC),
\]

where \( NSG \) is number of supervised study groups, \( NDT \) is number of supervised dissertation theses, \( NMT \) is number of supervised master theses, \( NBT \) is number of supervised bachelor theses, \( NPG \) is number of supervised scientific, professional and artistic activity groups and \( NSC \) is number of standard credits. Proposed number of standard credits is indicated in the Table 1. In the brackets after the number of standard credits \( NSC \) next to each item is indicated number of optimal occurrences \( NOO \) of given item (in total maximum of points):

Suggested number of standardised credits (formula for \( PP \)) Tab. 1

| \( NSC (NOO) \) | 4 (5) | 12 (1) | 6 (2) | 4 (3) | 4 (1) |

3. **Measurability of basic scientific performance**

Quality of university teacher’s SP per one academic year is defined by the following formula:

\[
SP = \sum_i (NPM)_i (NSC) + \sum_i (NSA)_i (NSC) + \\
+ \sum_j (NPA)_j (NSC) + \sum_j (NRP)_j (NSC) + \\
+ \sum_k (NQP)_k (NSC),
\]

where \( NPM \) is the number of published scientific and professional monographs, \( NSA \) is the number of published scientific articles, \( NPA \) is the number of reviewed scientific and professional papers, \( NRP \) is the number of cited scientific and professional papers, \( NSC \) is the number of...
standard credits. Proposed number of standard credits is indicated
in the Table 2. In the brackets after the number of standard credits
NSC next to each item is indicated number of optimal occur-
cences NOO of given item (in total maximum of 40 points if we do
not include separately evaluated item NPM):

Proposed number of standardized credits Tab. 2
(the formula for SP)

|                | NPM | NSA | NPA | NRP | NQP |
|----------------|-----|-----|-----|-----|-----|
| NSC (NOO)      | 20 (1) | 15 (1) | 10 (1) | 5 (2) | 5 (1) |

If university teacher receives at least 60 points for the basic
pedagogical performance PP and 40 points for basic scientific per-
formance SP then the set criteria were met and we can conclude
that standardized basic work performance was achieved. Formulas
for PP and SP may be modified if the ratio $PP : SP = 60 : 40$ is
maintained.

Pedagogical university teacher’s performance PP can be speci-
fied in a greater detail, however quality level and optimal quantifi-
cation of operations noted below are subjects to further research
and its results are beyond capacity of this article. Here we present
only a list of possible items [4].

4. Direct pedagogical activities:

Lecturing in full-time study programmes; facilitating seminars
and workshops in full-time study programmes; lecturing (consult-
ing) in doctoral studies; leading consultations in part-time study
programmes; leading excursions and internship programs for stu-
dents.

5. Indirect pedagogical activities:

preparation of lectures for full-time study programmes; prepa-
ration of seminars and workshops for full-time study programmes;
consulting hours for students (personal and electronic); prepara-
tion of lectures (consultations) for doctoral studies; preparation of
consultations for part-time study programmes; development of tests,
exam papers and tasks for semester and final evaluation of students;
evaluation of full-time and part-time students during the semester
(evaluation of course papers, projects, etc.); final evaluation of full-
time and part-time students; examination of doctoral students at
the end of course syllabus; membership in a state exam commission;
memorandum in rigorous commission; membership in commission
for examination of doctoral students; supervision of bachelor theses;
supervision of master theses; supervision of rigorous theses; sup-
ervision of dissertation theses; revision of bachelor theses; revision
of master theses; revision of rigorous theses; revision of dissertation
theses; revision of habilitation and inauguration papers; management
of SRA&D (Student research and development activities) and other
activities related to the pedagogical activities (record of results of
passing a subject in academic information system, creation of themes
for theses, preparation of written materials for students, etc.).

Scientific university teacher’s performance SP can be specified
in a greater detail. E.g. we could take into account percentage share
of an author in publications with more than one author as [2] and
[3] are. However quality level and optimal quantification of oper-
ations noted below are subject to further research and its results
are beyond capacity of this article. Here we present only a list of
possible items.

6. Scientific research and publication activities:

Creation of a scientific monograph; chapters in scientific mon-
ographs; academic textbook creation; chapters in academic textbooks;
scientific articles in journals; almanacs and monographs; presen-
tations in the conferences; reports about solved scientific research
tasks; copyright certificates, patents and inventions; published pro-
fessional books; chapters in professional books; textbooks for
primary and secondary schools; lecture scripts and notes; chapters
in lecture scripts and notes; professional articles in journals and
almanacs; abstracts, posters, slogans in technical terminology dic-
tionaries, standards, norms, translations; audio-visual works, works
of art; reviews, reports about research projects; leading the team
of authors creating monographs, textbooks, lecture scripts and notes;
implementation of research activities; management of grant and
non-grant projects (departmental, faculty, etc.) - team management,
administration; membership in a scientific school council; mem-
bership in a commission for study fields and joint commissions
for study fields; membership in a committee for project review;
membership in an editorial board of a journal; other activities con-
ected with scientific research (project development, organizational
work, conference management).

7. Other activities:

learning new knowledge; field of study supervisor; course coor-
dinator; member of rector’s advisory board; member of dean’s advi-
sory board; member of an accreditation committee (of ministry,
school, work group); member of the Academic Senate; position in
the Trade Union; Head of Department; Deputy Head of Depart-
ment; Department Secretary; training activities in the faculty (uni-
versity of 3rd age, professional training courses and seminars);
departmental meetings; ESF project coordinator; ESF project team
member.

8. The Coefficient of efficiency

The item Output in the formula for the Coefficient of efficiency
$E$ of an aggregated basic university teacher’s work performance
per one academic year can be determined by the formula:

$$Output = \frac{PP + SP}{100} \times ATW.$$
where \( ATW \) is an annual tariff wage (gross) determined by statute or other linking regulation.

The item \( Input \) in the formula for the Coefficient of efficiency \( E \) of an aggregated basic university teacher’s work performance per one academic year can be determined by the formula:

\[
Input = ATW + BNF,
\]

where \( BNF \) are financial benefits (gross) received above the framework \( ATW \).

The Coefficient of efficiency \( E \) of an aggregated basic university teacher’s work performance per one academic year can be determined by the formula:

\[
E = \frac{Output}{Input} = \frac{PP + SP}{100} \cdot \frac{ATW}{ATW + BNF}.
\]

In general, the Coefficient of efficiency \( E = \frac{PP + SP}{100} \cdot \frac{ATW}{ATW + BNF} \) is applied to a range of university teachers by a function of four independent real variables \( PP, SP, ATW \) and \( BNF \) where \( PP \geq 0, SP \geq 0, ATW > 0, BNF \geq 0, E \in [0, \infty) \). Balanced state \( E = 1 \) occurs, for example, when \( (PP, SP, ATW, BNF) = (60, 40, ATW, 0) \).

If we assume that \( BNF = 0 \) then \( E = \frac{PP + SP}{100} \). The performance of university teacher can be stated in percentage, it applies that \( E(\%) = \frac{ATW}{PP + SP} \) if \( BNF = 0 \).

9. The specific model situation and its evaluation

Suppose that the organisational unit of university consists of \( n \geq 1, n \in N \) teachers. This may be one teacher, a group of several professors, several associated professors, several associates, several assistants in the department, but also a group of all teachers in the department, and so forth.

The Coefficient of efficiency \( E \) of the aggregated basic university teacher’s work performance \( (n = 1, i = 1) \) and of a group of university teachers \( (n > 1, i = 1, 2, \ldots, n) \) per one academic year, provided that the value of the group member’s performance \( PP + SP \) is comparable, can be determined by the formula:

\[
E = \frac{Output}{Input} = \frac{\sum_i (PP) (SP)}{100n} \frac{\sum_i (ATW)}{\sum_i (ATW) (BNF)} ,
\]

where the expression \( \frac{\sum_i (PP) (SP)}{100n} \) represents the mean value of random variable \( X = \frac{(PP)}{100} + \frac{(SP) + (SP)}{100} + \ldots \),

\[
\sum_i (ATW), \text{ the expression } E \text{ of the aggregated basic university teacher’s work performance per one academic year can be estimated, for example, when } (PP, \ldots, BNF) = (60, 40, ATW, 0) \).

The Coefficient of efficiency \( E \) of the aggregated basic university teacher’s work performance \( (n = 1, i = 1) \) and of a group of university teachers \( (n > 1, i = 1, 2, \ldots, n) \) per one academic year, provided that the value \( (ATW + BNF) \) of the group members is comparable and the random variable \( Y = (E_1, E_2, \ldots, E_n) \) represents such Coefficients of efficiency of the aggregated basic university teacher’s work performance within considered group that belong to normal statistical distribution can be determined by the formula:

\[
E = \frac{Output}{Input} = \frac{\sum_i (PP) + (SP)}{100 \sum_i (ATW) + (BNF)^\prime}.
\]

The Coefficient of efficiency \( E \) of the aggregated basic university teacher’s work performance \( (n = 1, i = 1) \) and of a group of university teachers \( (n > 1, i = 1, 2, \ldots, n) \) per one academic year, provided that the value \( (ATW + BNF) \) of the group members is comparable and the random variable \( Y = (E_1, E_2, \ldots, E_n) \) represents such Coefficients of efficiency of the aggregated basic university teacher’s work performance within considered group that belong to normal statistical distribution can be determined by the formula:

\[
E = \frac{Output}{Input} = \frac{\sum_i (PP) + (SP)}{100 \sum_i (ATW) + (BNF)^\prime}.
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\[
E = \frac{Output}{Input} = \frac{\sum_i (PP) + (SP)}{100 \sum_i (ATW) + (BNF)^\prime}.
\]
y = \frac{PP + SP}{100E_o} - 1 \text{ATW}.

10. Example for calculating the Coefficient of efficiency and the amount of monetary compensation

Consider the model situation according to Table 3 for two employees Emp1, Emp2.

Calculate the Coefficient of efficiency \( E_1 \) of the aggregated basic work performance of the employee Emp1 and the Coefficient of efficiency \( E_2 \) of the aggregated basic work performance of the employee Emp2.

Calculate the Coefficient of efficiency \( E_3 \) of the aggregated basic work performance of the group of employees Emp1 and Emp2 by applying the formula for comparable values \( PP + SP \).

Calculate the Coefficient of efficiency \( E_4 \) of the aggregated basic work performance of the group of employees Emp1 and Emp2 by applying the formula for incomparable values \( PP + SP \).

Calculate the Coefficient of efficiency \( E_5 \) of the aggregated basic work performance of the group of employees Emp1 and Emp2 by applying the formula for comparable values \( ATW + BNF \).

Performance and income of workers Tab. 3

| \( PP \) | \( SP \) | \( ATW \) | \( BNF \) | \( PP + SP \) | \( ATW + BNF \) |
|-----|-----|-----|-----|-----|-----|
| 59  | 30  | 1000| 200 | 89  | 1200|
| 56  | 48  | 1200| 300 | 104 | 1500|

Values \( ATW \) and \( BNF \) are presented in theoretical monetary terms. Then we have

\[
E_1 = \frac{PP + SP}{100} \frac{ATW}{ATW + BNF} = \frac{89}{100} \frac{1000}{1000 + 1200} \approx 0.741666666
\]

\[
E_2 = \frac{PP + SP}{100} \frac{ATW}{ATW + BNF} = \frac{104}{1200} \frac{1200}{1200 + 1500} = 0.832
\]

\[
E_3 = \frac{\sum_{i} (PP_i) + (SP_i)}{100n} \frac{\sum_{i} (ATW_i)}{\sum_{i} (ATW_i) + (BNF_i)} = \frac{89 + 104}{200} \frac{1000 + 1200}{1200 + 1500} \approx 0.786296296
\]

\[
E_4 = \frac{\sum_{i} (PP_i)}{100} \frac{(ATW_i)}{\sum_{i} (ATW_i) + (BNF_i)} = \frac{89}{100} \frac{1000}{1200 + 1500} \approx 0.791851851
\]

\[
E_5 = \frac{E_i + E_2}{2} = median(E_i, E_2) = \frac{0.741666666 + 0.832}{2} \approx 0.786833333
\]

We can conclude from the calculations that the return of the invested financial resources in case the employee Emp1(Emp2) is at the level of 74.17%(83.20%).

The Coefficient of efficiency \( E_3(\%) \) of the aggregated basic work performance of the group of employees Emp1 and Emp2, provided that the values \( PP + SP \) of the group members are comparable, is on the level 78.63%.

The Coefficient of efficiency \( E_4(\%) \) of the aggregated basic work performance of the group of employees Emp1 and Emp2, provided that the values \( PP + SP \) of the group members are incomparable, is on the level 79.19%.

The Coefficient of efficiency \( E_5(\%) \) of the aggregated basic work performance of the group of employees Emp1 and Emp2, provided that the values \( ATW + BNF \) of the group members are comparable, is on the level 78.68%.

For given model situation applies that \( E_3(\%) = E_4(\%) = E_5(\%) = 79\% \).

Consider that the optimum level of the Coefficient of efficiency of the aggregated basic university teacher’s work performance per one academic year is the value \( E_0=0.832 \). Then the employee Emp2 deserves zero cash compensation \( x_2 = 0 \) and the employee deserves payroll deduction in a form of single monetary compensation \( x_1, x_1 \geq 0 \):

\[
x_i = BNF + \left(1 - \frac{PP + SP}{100E_i}\right)ATW = \frac{200}{1 - \frac{89}{83.2}} \frac{1000}{1000} \approx 130.2884615
\]

of theoretical monetary units.

Consider that the optimum level of the Coefficient of efficiency of the aggregated basic university teacher’s work performance per one academic year is the value \( E_0=0.741666666 \). Then the employee Emp1 deserves zero cash compensation \( y_1 = 0 \) and the employee Emp2 deserves payroll bonus in a form of single monetary compensation \( y_2, y_2 \geq 0 \):
of theoretical monetary units.

\[ y_2 = -BNF + \left( \frac{PP + SP}{100E_v} - 1 \right) ATW = \]
\[ = -300 + \left( \frac{104}{74.1666666} - 1 \right) 1200 \approx 182.6966307 \]

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