APPENDICES

Appendix 1

Evaluation questionnaire

Note: in group G1 there was no question 10 regarding participation in live video-classes, and in group G2 there was no question 11 regarding video recordings from the classes. The rest of the questions appeared in each group in identical form.

TIME-consumption

Estimate how many hours, on average, were required from you to devote to learning activities listed below.

1. CLASSES

Average number of hours spent on a single class: ……….

(participation in live classes + watching videos from classes + own work devoted to acquire knowledge from video tutorials, tasks, posts on discussion forums, searching for additional information on the Internet)

2. HOMEWORKS

Average number of hours spent on doing a single homework: ……….

3. TOTAL

Taking into account the answers above, try to estimate the total number of working/learning hours required for participation in the entire course: ……….

(participation in classes + preparation for classes + homeworks)

4. COMPARATIVE EVALUATION

How do you rate the time-consumption of this course in comparison with other courses taken so far (on a scale from 1 to 5, where: 1 - very low time consumption; 5 - very high time consumption).

MATERIALS FOR CLASSES

Assess the usefulness of individual forms of materials in acquiring knowledge and skills on a scale of 1-5, where: 1 - very low usefulness; 5 - very high suitability.

5. Self-study tutorials for classes

6. Tasks for classes

7. Solutions for tasks

8. Homeworks

9. Discussion forums

10. Participation in live video-lectures

11. Videos for classes (pre-prepared or recordings from live classes)

COURSE EVALUATION

Rate the course on a scale of 0–5, where: 0 – very low grade; 5 – very high grade.

12. Satisfaction with participation in the course

13. Increase in knowledge and skills

14. Assessment of the level of the course in comparison with others, so far completed

15. Does the course encourage further studies on the subject?

16. Overall evaluation of the course

QUALITATIVE EVALUATION

17. Please enter any remarks, comments and suggestions regarding the subject of the course, materials and the method of conducting classes:

INFORMATION ABOUT YOUR STUDIES

18. Cycle of studies
    - Bachelor
    - Master
    - PhD

19. Your average grade from the last year
    - <3
    - [3; 3.5)
    - [3.5; 4)
    - [4; 4.5)
    - ≥4.5

Appendix 2
Analysis of the statistical significance of differences in the number of points scored between the groups

Part 1. Checking the normality of distribution.

```
# Shapiro-Wilk test for normality of distribution in subsamples
shapiro.test (tab $ Points [tab $ Group1 == 'G1'])
## Shapiro-Wilk normality test
## data: tab $ Points [tab $ Group1 == "G1"]
## W = 0.96503, p-value = 0.4341
# Conclusion: there are no grounds to reject H0 about normal distribution.

shapiro.test (tab $ Points [tab $ Group1 == 'G2'])
```

Shapiro-Wilk normality test
data: tab $ Points [tab $ Group1 == "G2"]
W = 0.94841, *p-value* = 0.4318
Conclusion: there are no grounds to reject H0 about normal distribution

shapiro.test (tab $ Points [tab $ Group1 == 'G3'])
Shapiro-Wilk normality test
data: tab $ Points [tab $ Group1 == "G3"]
W = 0.92526, *p-value* = 0.04688
Conclusion: we reject H0 about normal distribution.

Conclusion: in one of the groups (G3) the null hypothesis of the normality of distribution was rejected, but due to small deviations from normality (kurtosis 2.470153, skewness -0.5799455) and low sensitivity of the ANOVA model to the lack of normality of the distribution of the dependent variable known in literature, it was decided to first perform a parametric analysis. In the next step, the results will be compared with the results of a non-parametric analysis.

Part 2. Checking the equality of variances.

Bartlett's test for equality of variance

bartlett.test (Points ~ Group1, data = tab)

Bartlett test of homogeneity of variances

date: Points by Group1

Bartlett's K-squared = 1.9336, *df* = 2, *p-value* = 0.3803

Conclusion: there is no reason to reject H0 on the equality of variance.

Conclusion: There is no reason to reject the null hypothesis of homogeneity of variances, so a version of the ANOVA test will be performed for equal variances.

Part 3. Checking differences between groups.

summary (aov (Points ~ Group1, data = tab))

Df Sum Sq Mean Sq F value Pr (> F)

Group1 2 633 316.4 1.329 0.27

Residuals 79 18 805 238.0

Conclusion: Variable Group1 irrelevant, to double check we perform post-hoc analysis according to Tukey's proposal.

TukeyHSD (aov (Points ~ Group1, data = tab))

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov (formula = Points ~ Group1, data = tab)

$ Group1

diff lwrupr p adj

G2-G1 6.645421 -3.412444 16.703286 0.2609984

G3-G1 1.604335 -8.159880 11.368550 0.9186900

G3-G2 -5.041086 -15.181760 5.099589 0.4641272

Conclusion: insignificant differences for all pairs of subgroups.

Conclusion: there are no statistically significant differences between the results in the individual groups.

Part 4. Checking differences between groups – a non-parametric test.

Checking the assumption that residuals are normal:
shapiro.test (x = residuals (object = aov (Points ~ Group1, data = tab)))
Shapiro-Wilk normality test
data: residuals (object = aov (Points ~ Group1, data = tab))
W = 0.95892, *p-value* = 0.01019
Conclusion: the residuals are not normally distributed, so we conduct a nonparametric test.

kruskal.test (Points ~ Group1, data = tab)
Kruskal-Wallis rank sum test
date: Points by Group1
Kruskal-Wallis chi-squared = 3.1472, *df* = 2, *p-value* = 0.2073
Conclusion: the variable Group1 is irrelevant, to be sure we perform post-hoc analysis.

kruskalmc (tab $ Points, tab $ Group1)
Multiple comparison test after Kruskal-Wallis
p-value: 0.05
Comparisons
obs.difcritical.dif difference
G1-G2 11.524138 15.55979 FALSE
G1-G3 5.009852 15.10550 FALSE
G2-G3 6.514286 15.68790 FALSE
Conclusion: insignificant differences for all pairs of subgroups (at a significance level of 5%).
Conclusion: to double check, a non-parametric Kruskal-Wallis test was also performed, which confirmed the lack of statistically significant differences between the results in individual groups.

Appendix 3
Analysis of the statistical significance of differences in time spent on individual classes between groups

Part 1. Checking the normality of distribution.

Shapiro-Wilk test for normality of distribution in subsamples
shapiro.test (tab $ Classes [tab $ Group2 == 'G1'])
Shapiro-Wilk normality test
date: tab $ Classes [tab $ Group2 == "G1"]
W = 0.87724, *p-value* = 0.00419
Conclusion: we reject H0 about the normality of distribution.

shapiro.test (tab $ Classes [tab $ Group2 == 'G2'])
Shapiro-Wilk normality test
date: tab $ Classes [tab $ Group2 == "G2"]
W = 0.84078, *p-value* = 0.001481

Conclusion: we reject H0 about the normality of distribution.

shapiro.test (tab $ Classes [tab $ Group2 == 'G3'])
Shapiro-Wilk normality test
date: tab $ Classes [tab $ Group2 == "G3"]
W = 0.96728, *p-value* = 0.6243
Conclusion: there are no reason to reject H0 about normal distribution.

Conclusion: The distribution of the variable in the subgroups is not normal, therefore a non-parametric analysis will be performed.

Part 2. Checking the equality of variance (additional - to check the differentiation between groups).

Levene's test for equality of variance (nonparametric)
leveneTest (Group2, data = tab)
Levene's Test for Homogeneity of Variance (center = median)
Df F value Pr (> F)
group 2 0.9998 0.3731
71
Conclusion: there is no reason to reject H0 on the equality of variance.

Fligner-Killeen test for equality of variance (nonparametric)
fligner.test (Classes ~ Group2, data = tab)
Fligner-Killeen test of homogeneity of variances
date: Classes by Group2
Fligner-Killeen: *med chi-squared* = 3.4317, *df* = 2, *p-value* = 0.1798
Conclusion: there is no reason to reject H0 on the equality of variance.

Conclusion: on the basis of non-parametric Levene and Fligner-Killeen tests, it was assumed that the variances are equal. However, due to the lack of normal distribution, the differences between the groups will be checked with a non-parametric test.

Part 3. Checking differences between groups – a non-parametric test.

kruskal.test (Classes ~ Group2, data = tab)

Kruskal-Wallis rank sum test

date: Classes by Group2

Kruskal-Wallis chi-squared = 18.823, *df* = 2, *p-value* = 8.176e-05

Conclusion: Group2 variable is important, so we do post-hoc analysis.

kruskalmc (tab $ Classes, tab $ Group2, probs = 0.05)

Multiple comparison test after Kruskal-Wallis

p-value: 0.05

Comparisons

obs.difcritical.dif difference

G1-G2 25.88426 14.44355 TRUE

G1-G3 12.43317 14.60883 FALSE

G2-G3 13.45109 15.02297 FALSE

Conclusion: significant difference only between G1 and G2 subgroups (at a significance level of 5%).

Conclusion: a non-parametric Kruskal-Wallis test showed a statistically significant difference between the results for the G1 and G2 groups.

Appendix 4
Statistical significance of differences in time spent on single homework between groups

Part 1. Checking the normality of distribution.

Shapiro-Wilk test for normality of distribution in subsamples
Shapiro-Wilk normality test
data: tab $ Homework [tab $ Group2 == "G1"]
W = 0.94496, *p-value* = 0.1614
Conclusion: there are no grounds to reject H0 about normal distribution.

Shapiro-Wilk normality test
data: tab $ Homework [tab $ Group2 == "G2"]
W = 0.79545, *p-value* = 0.0002484
Conclusion: we reject H0 about the normality of distribution.

Shapiro-Wilk normality test
data: tab $ Homework [tab $ Group2 == "G3"]
W = 0.95195, *p-value* = 0.321
Conclusion: there are no grounds to reject H0 about normal distribution.

Conclusion: since the analyzed variable does not have a normal distribution in one of the three groups (G2), a non-parametric analysis will be performed and then the results will be compared with the results from the parametric analysis.

Part 2. Checking the equality of variance (additional – to check the differentiation between groups).

Levene's test for equality of variance (nonparametric)
Levene's Test for Homogeneity of Variance (center = median)
Df F value Pr (> F)
group 2 2.6648 0.07657
71
Conclusion: there is no reason to reject H0 on the equality of variance.

Fligner-Killeen test for equality of variance (nonparametric)
fligner.test (WorkHome ~ Group2, data = tab)
Fligner-Killeen test of homogeneity of variances
date: Homework by Group2
Fligner-Killeen: med chi-squared = 2.3649, *df* = 2, *p-value* = 0.3065
Conclusion: there is no reason to reject H0 on the equality of variance.

Conclusion: on the basis of non-parametric Levene and Fligner-Killeen tests, it was assumed that the variances are equal. However, due to the lack of normal distribution, the differences between the groups will be checked with a non-parametric test.

Part 3. Checking differences between groups – a non-parametric test.

kruskal.test (Homework ~ Group2, data = tab)

Kruskal-Wallis rank sum test

date: Homework ~ Group2

Kruskal-Wallis chi-squared = 1.377, *df* = 2, *p-value* = 0.5023

Conclusion: the variable Group2 is irrelevant, to be sure we perform post-hoc analysis.

kruskalmc (tab $ Homework, tab $ Group2, probs = 0.05)

Multiple comparison test after Kruskal-Wallis

p-value: 0.05

Comparisons

obs.difcritical.dif difference

G1-G2 5.236111 14.44355 FALSE

G1-G3 6.690821 14.60883 FALSE

G2-G3 1.454710 15.02297 FALSE

Conclusion: insignificant differences for all pairs of subgroups (at a significance level of 5%).

Conclusion: a non-parametric Kruskal-Wallis test showed no statistically significant differences between the results in individual groups.

Part 4. Checking differences between groups – parametric test.

summary (aov (Homework ~ Group2, data = tab))

Df Sum Sq Mean Sq F value Pr (> F)

Group2 2 109.4 54.71 1.779 0.176

Residuals 71 2183.4 30.75

Conclusion: Variable Group2 irrelevant, to be sure we perform post-hoc analysis according to Tukey's proposal.

TukeyHSD (aov (Homework ~ Group2, data = tab))

Tukey multiple comparisons of means

95% family-wise confidence level

##

Fit: aov (formula = Homework ~ Group2, data = tab)

##

$ Group2

diff lwrupr p adj

G2-G1 2.93287 -0.7913322 6.657073 0.1504344

G3-G1 1.29066 -2.4761601 5.057481 0.6917972

G3-G2 -1.64221 -5.5158131 2.231393 0.5699931

Conclusion: insignificant differences for all pairs of subgroups.

Conclusion: for certainty, the parametric F test and post-hoc analysis according to Tukey's proposal were also performed, which confirmed the lack of statistically significant differences between the results in individual groups.

Appendix 5
Analysis of the statistical significance of differences in the total time spent on the entire course between the groups

Part 1. Checking the normality of distribution.

Shapiro-Wilk test for normality of distribution in subsamples
Shapiro-Wilk normality test
data: tab $ whole course [tab $ Group 2 == "G1"]
W = 0.94581, *p-value* = 0.1694
Conclusion: there are no grounds to reject H0 about normal distribution.

Shapiro-Wilk normality test
data: tab $ whole course [tab $ Group 2 == "G2"]
W = 0.80368, *p-value* = 0.0003385
Conclusion: we reject H0 about the normality of distribution.

Shapiro-Wilk normality test
data: tab $ whole course [tab $ Group 2 == "G3"]
W = 0.97362, *p-value* = 0.7748
Conclusion: there are no grounds to reject H0 about normal distribution.

Conclusion: since the analyzed variable does not have a normal distribution in one of the three groups (G2), a non-parametric analysis will be performed and then the results will be compared with the results from the parametric analysis.

Part 2. Checking the equality of variance (additional - to check the differentiation between groups).
Levene test for equality of variance (nonparametric)
Levene Test (whole course ~ Group 2, data = tab)
Levene Test for Homogeneity of Variance (center = median)
Df F value Pr (> F)
group 2 0.3405 0.7125
71
Conclusion: there is no reason to reject H0 on the equality of variance.

Fligner-Killeen test for equality of variance (nonparametric)
fligner.test (whole course ~ Group 2, data = tab)

Fligner-Killeen test of homogeneity of variances
data: whole course by Group2
Fligner-Killeen: med chi-squared = 0.12342, *df* = 2, *p-value* = 0.9402
Conclusion: there is no reason to reject H0 on the equality of variance.

Conclusion: on the basis of non-parametric Levene and Fligner-Killeen tests, it was assumed that the variances are equal. However, due to the lack of normal distribution, the differences between the groups will be checked with a non-parametric test.

Part 3. Checking differences between groups – a non-parametric test.

Kruskal-Wallis test (whole course ~ Group2, data = tab)

Kruskal-Wallis rank sum test

data: whole course by Group2

Kruskal-Wallis chi-squared = 9.8542, *df* = 2, *p-value* = 0.007248

Conclusion: Group2 variable is important, so we do post-hoc analysis.

Kruskal mc (tab $ C whole course, tab $ Group2)

Multiple comparison test after Kruskal-Wallis

p-value: 0.05

Comparisons

obs.difcritical.dif difference

G1-G2 18.817130 14.44355 TRUE

G1-G3 10.274557 14.60883 FALSE

G2-G3 8.542572 15.02297 FALSE

Conclusion: significant difference only between G1 and G2 subgroups (at a significance level of 5%).

Conclusion: a non-parametric Kruskal-Wallis test showed a statistically significant difference between the results for the G1 and G2 groups.

Part 4. Checking differences between groups - parametric test.

summary (aov (whole course ~ Group2, data = tab))

Df Sum Sq Mean Sq F value Pr (> F)

Group2 2 3492 1746 5.092 0.00858

Residuals 71 24 350 343

Conclusion: The variable Group2 is significant, so we do post-hoc analysis.

TukeyHSD (aov (whole course ~ Group2, data = tab))

Tukey multiple comparisons of means

95% family-wise confidence level

##

Fit: aov (formula = whole course ~ Group2, data = tab)

##

$ Group2

diff lwrupr p adj

G2-G1 16.546296 4.109469 28.983124 0.0060253

G3-G1 6.854267 -5.724881 19.433415 0.3974709

G3-G2 -9.692029 -22.627773 3.243715 0.1790867

Conclusion: significant difference only between the G1 and G2 subgroups.

Conclusion: for certainty, the parametric F test and post-hoc analysis according to Tukey's proposal were also performed, which confirmed the statistically significant difference between the results for the G1 and G2 groups.