sesame

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```
library(xlsx)
```

```
## Loading required package: rJava
```

```
## Loading required package: xlsxjars
```

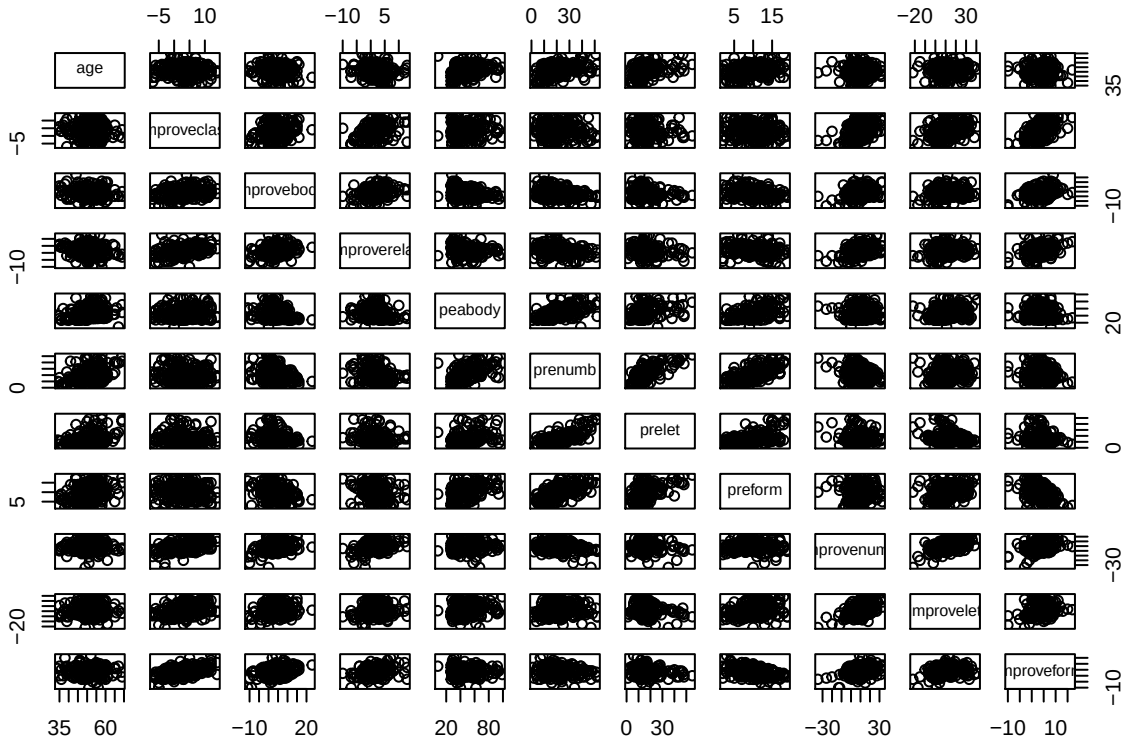
```
SS=read.xlsx('sesame.xlsx', sheetIndex = 1)
```

```
SS$improvenumb=SS$postnumb-SS$prenumb
SS$improvelet=SS$postlet-SS$prelet
SS$improveform=SS$postform-SS$preform
SS$improvebody=SS$postbody-SS$prebody
SS$improverelat=SS$postrelat-SS$prerelat
SS$improveclasf=SS$postclasf-SS$preclasf
```

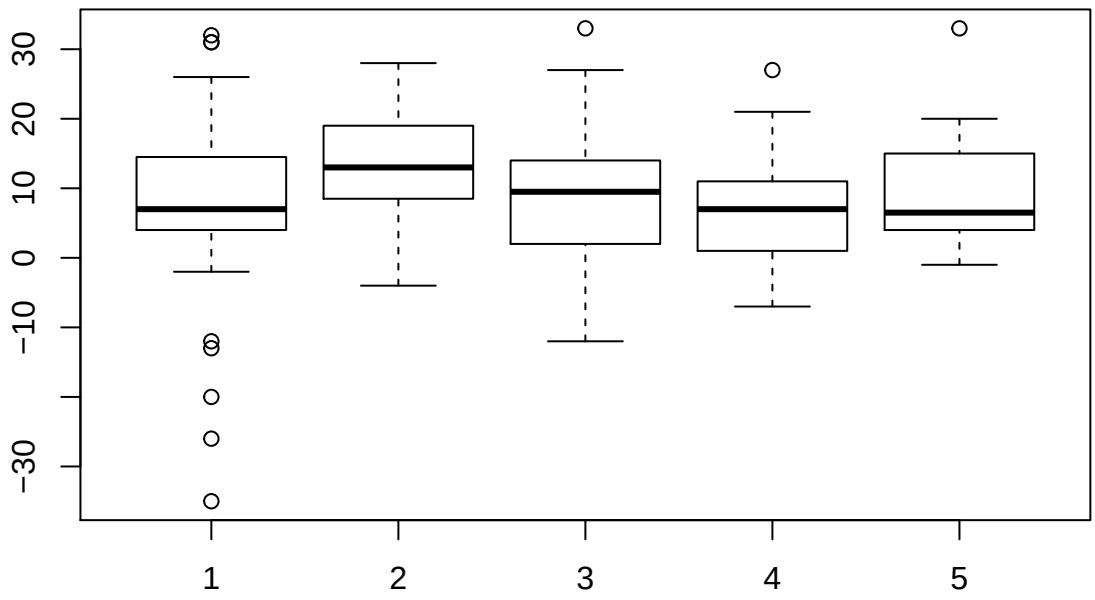
```
site1=SS[SS$site==1,]
site2=SS[SS$site==2,]
site3=SS[SS$site==3,]
site4=SS[SS$site==4,]
site5=SS[SS$site==5,]
```

```
sesame=SS
sesame$s1[sesame$site==1]=1
sesame$s1[sesame$site>1]=0
sesame$s2[sesame$site==2]=1
sesame$s2[sesame$site>2]=0
sesame$s2[sesame$site<2]=0
sesame$s3[sesame$site==3]=1
sesame$s3[sesame$site>3]=0
sesame$s3[sesame$site<3]=0
sesame$s4[sesame$site==4]=1
sesame$s4[sesame$site>4]=0
sesame$s4[sesame$site<4]=0
sesame$sex[sesame$sex==2]=0
sesame$setting[sesame$setting==2]=0
sesame$viewenc[sesame$viewenc==2]=0
sesame$vc1[sesame$viewcat==1]=1
sesame$vc1[sesame$viewcat>1]=0
sesame$vc2[sesame$viewcat==2]=1
sesame$vc2[sesame$viewcat>2]=0
sesame$vc2[sesame$viewcat<2]=0
sesame$vc3[sesame$viewcat==3]=1
sesame$vc3[sesame$viewcat>3]=0
sesame$vc3[sesame$viewcat<3]=0
```

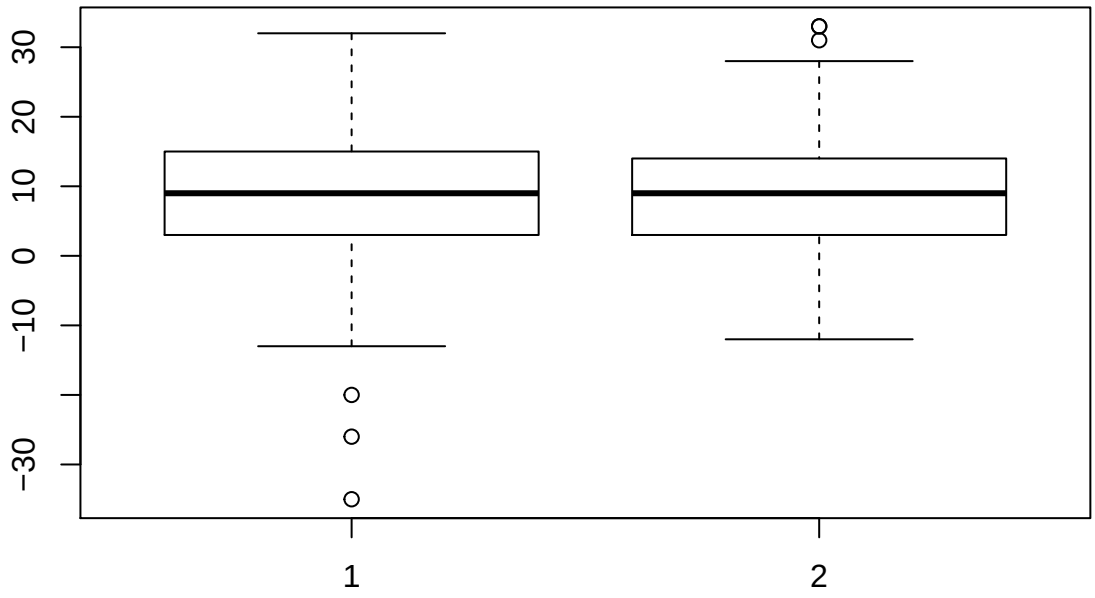
```
attach(SS)
pairs(~age+improveclasf+improvebody+improverelat+peabody+prenumb+prelet+preform+improvenumb+improvelet+
```



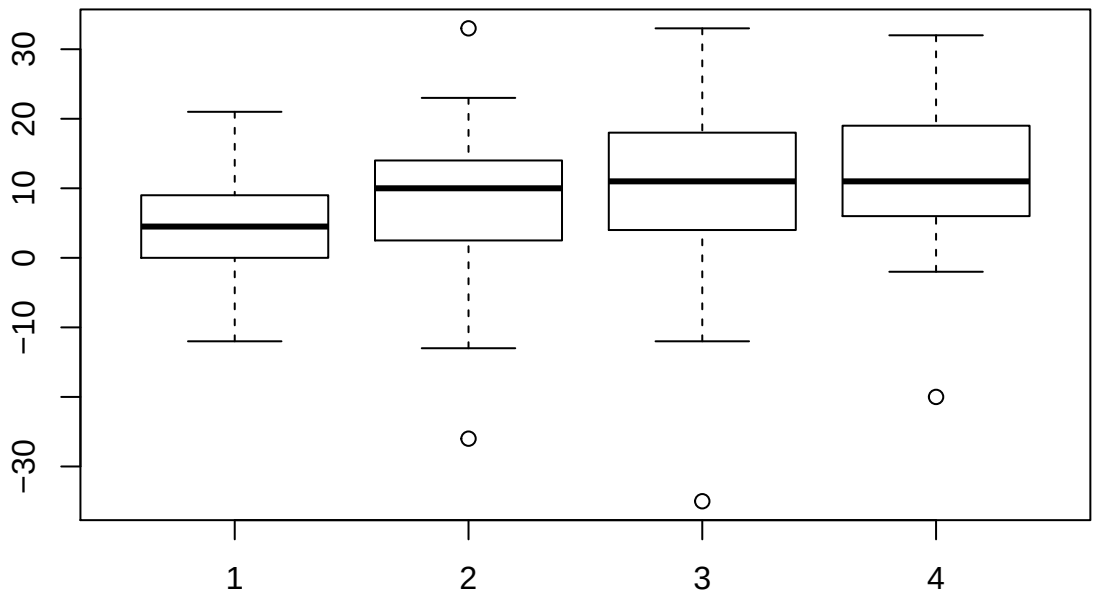

```
boxplot(improvenumb~site)
```



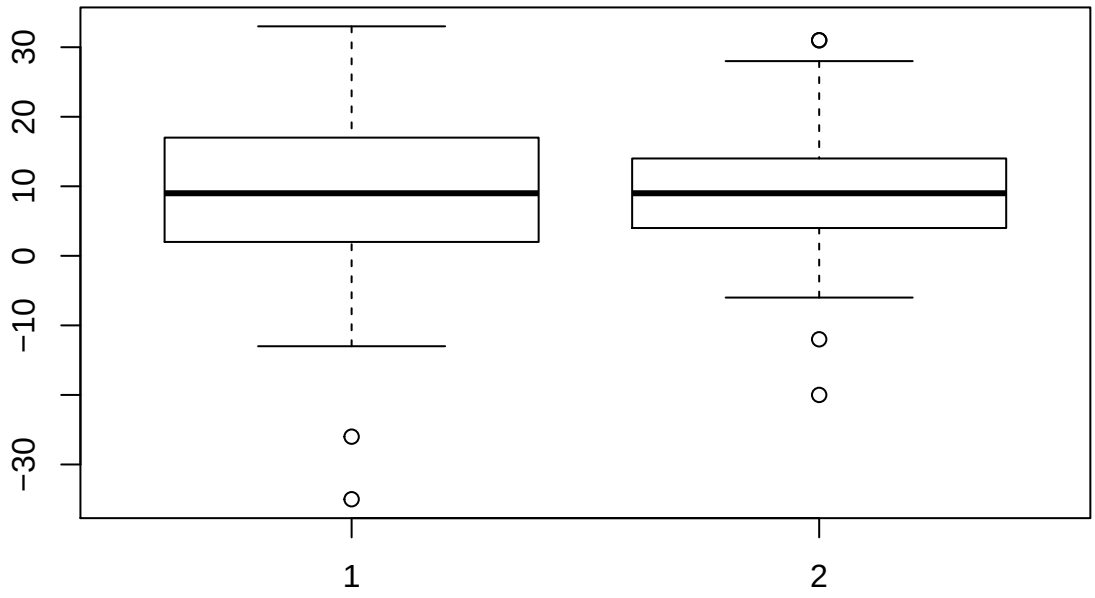

```
boxplot(improvenumb~sex)
```



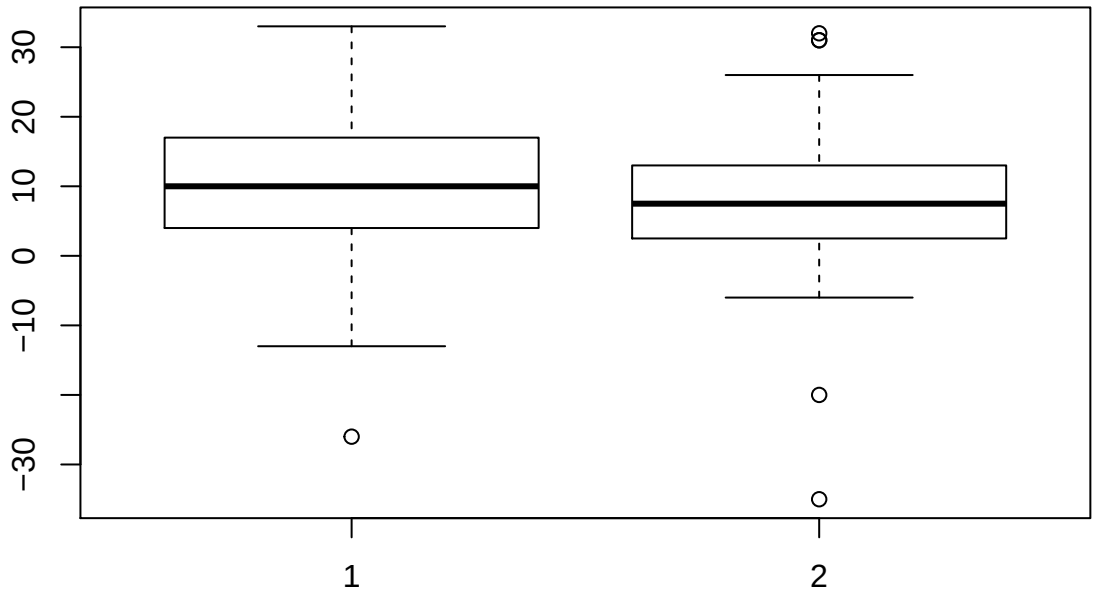

```
boxplot(improvenumb~viewcat)
```



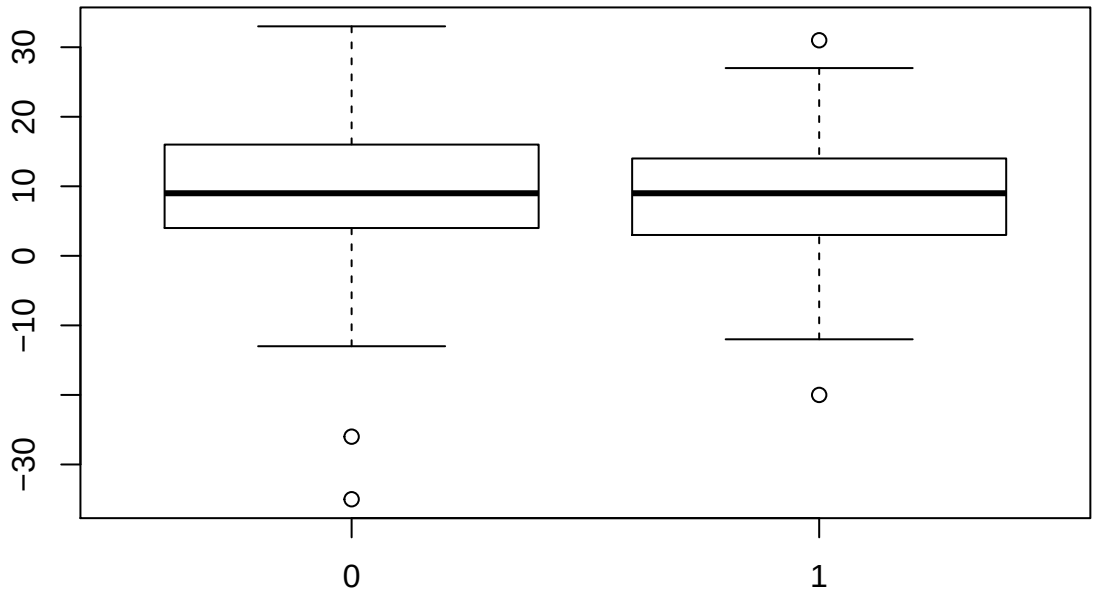

```
boxplot(improvenumb~setting)
```



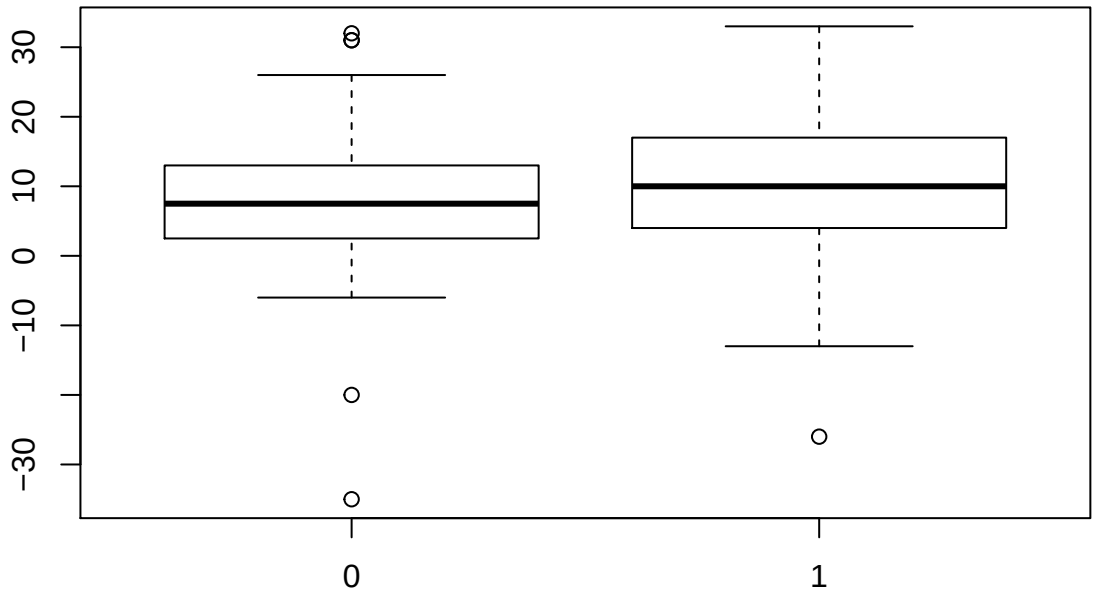

```
boxplot(improvenumb~viewenc)
```



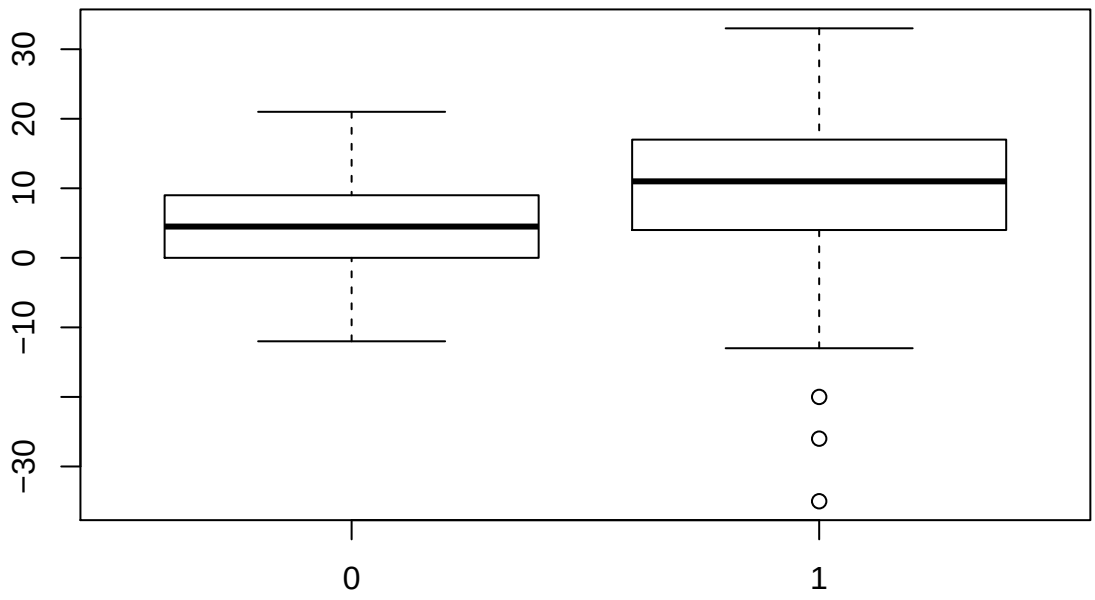

```
boxplot(improvenumb~agecat)
```



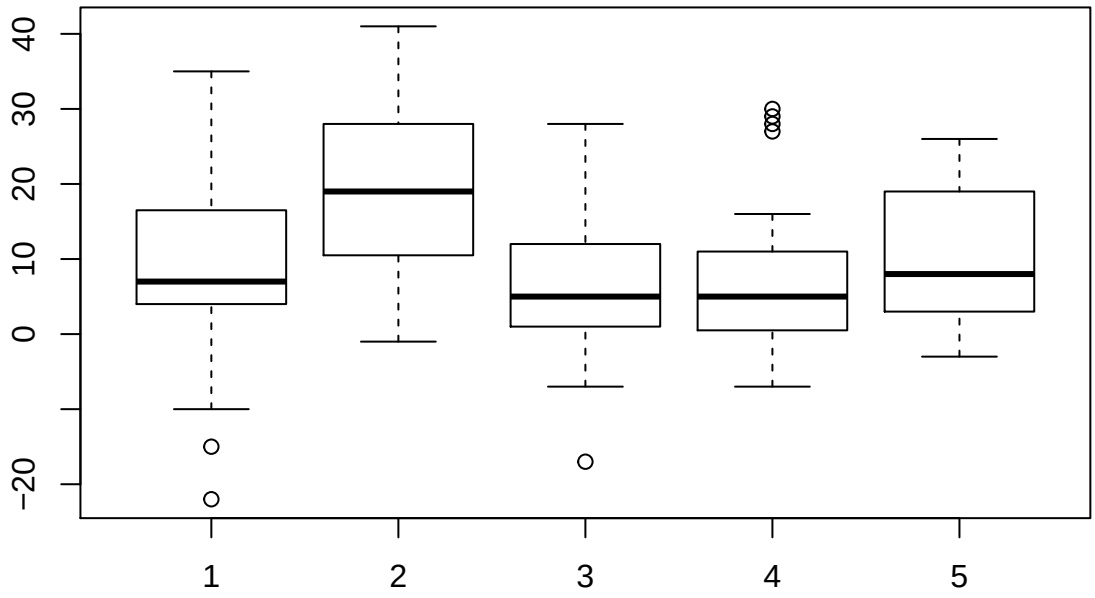

```
boxplot(improvenumb~encour)
```



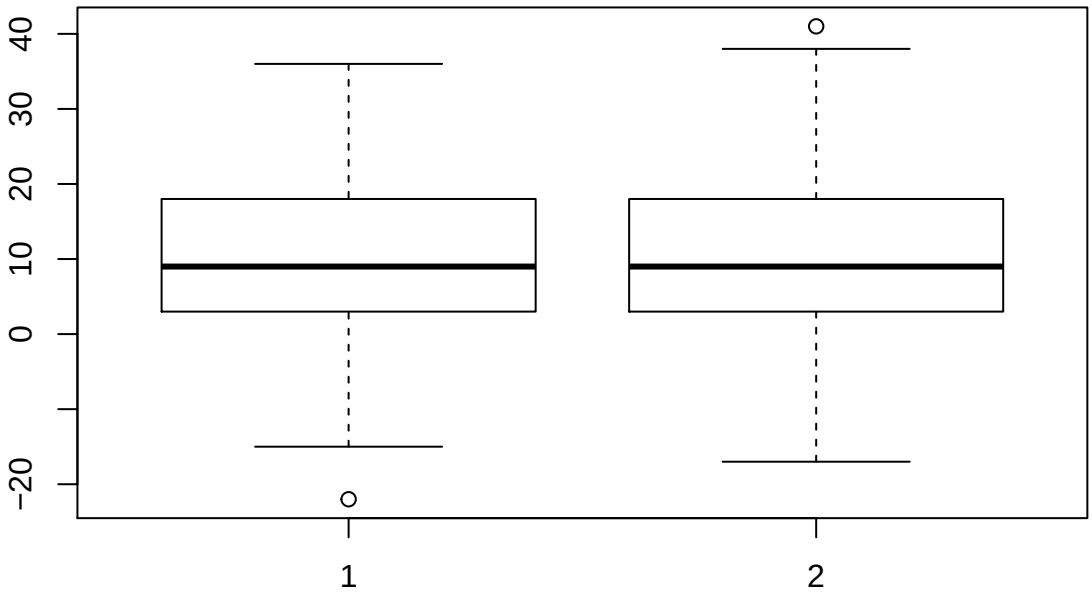

```
boxplot(improvenumb~regular)
```



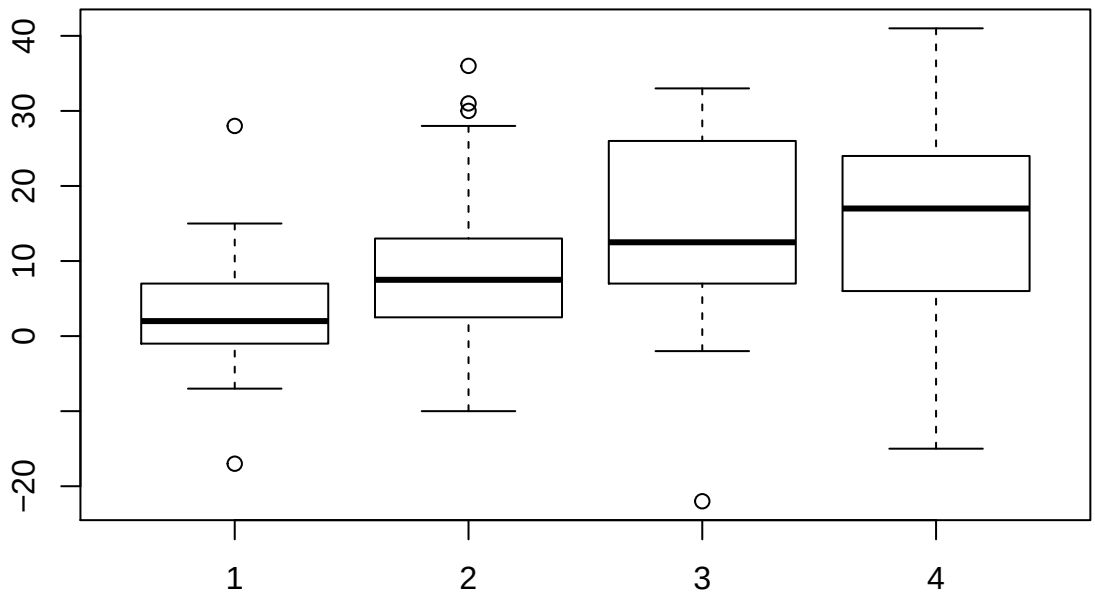

```
boxplot(improvelet~site)
```



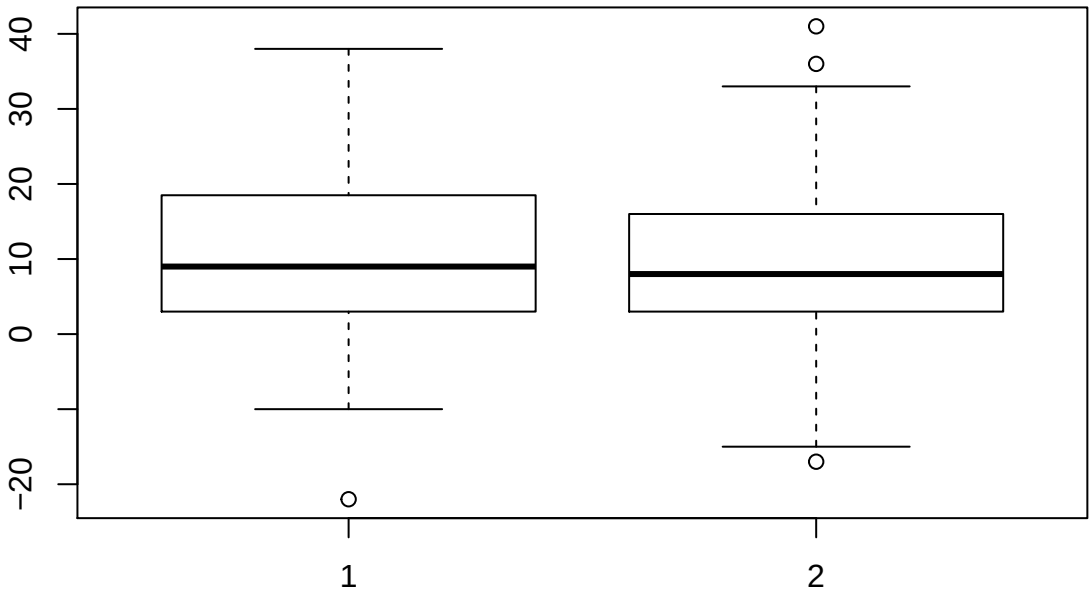

```
boxplot(improvelet~sex)
```



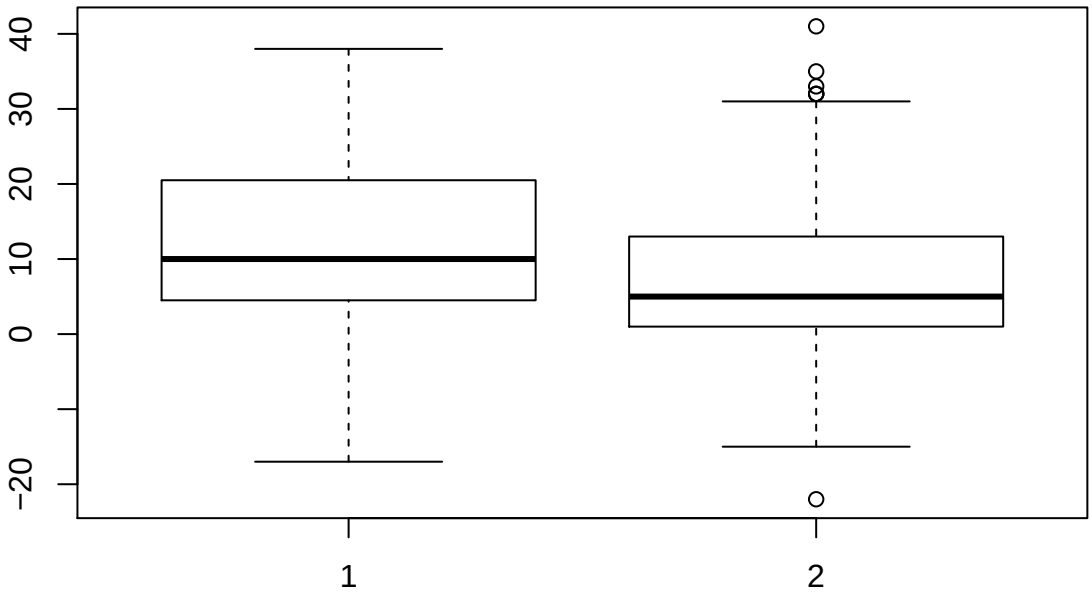

```
boxplot(improvelet~viewcat)
```



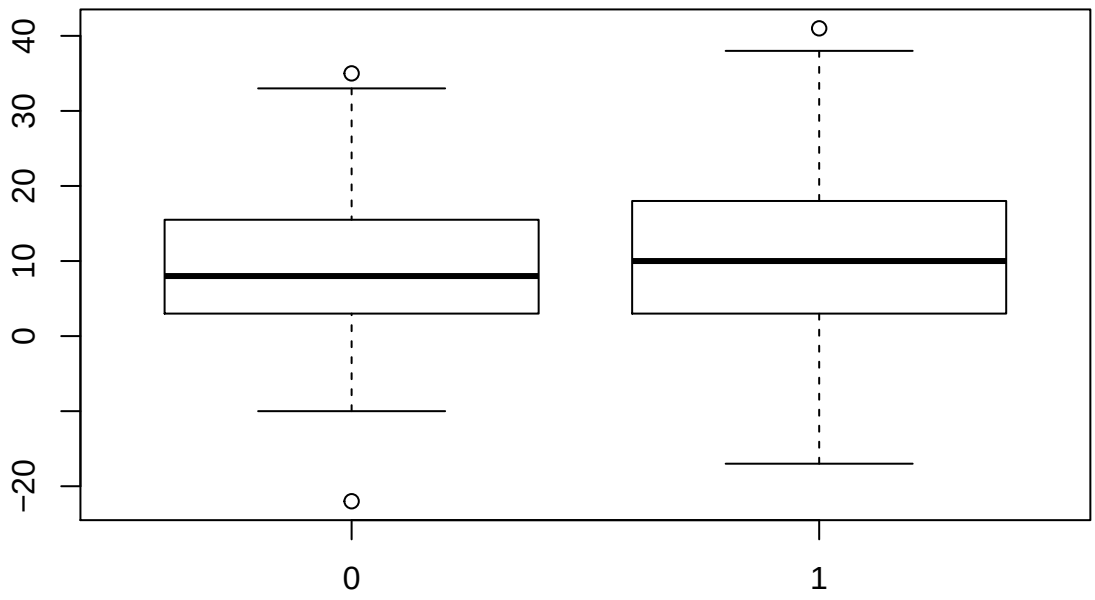

```
boxplot(improvelet~setting)
```



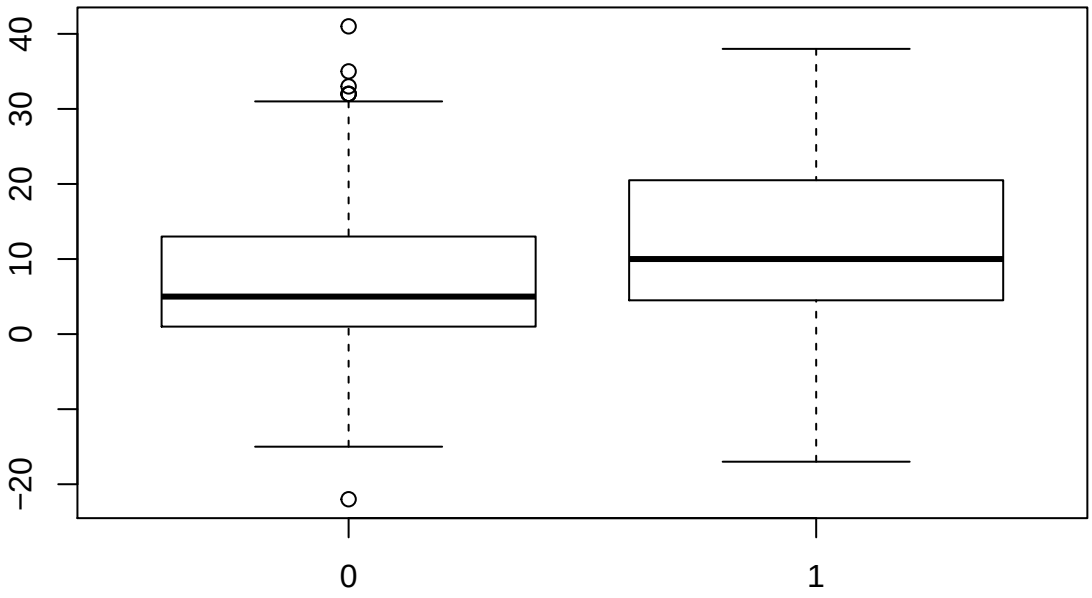

```
boxplot(improvelet~viewenc)
```



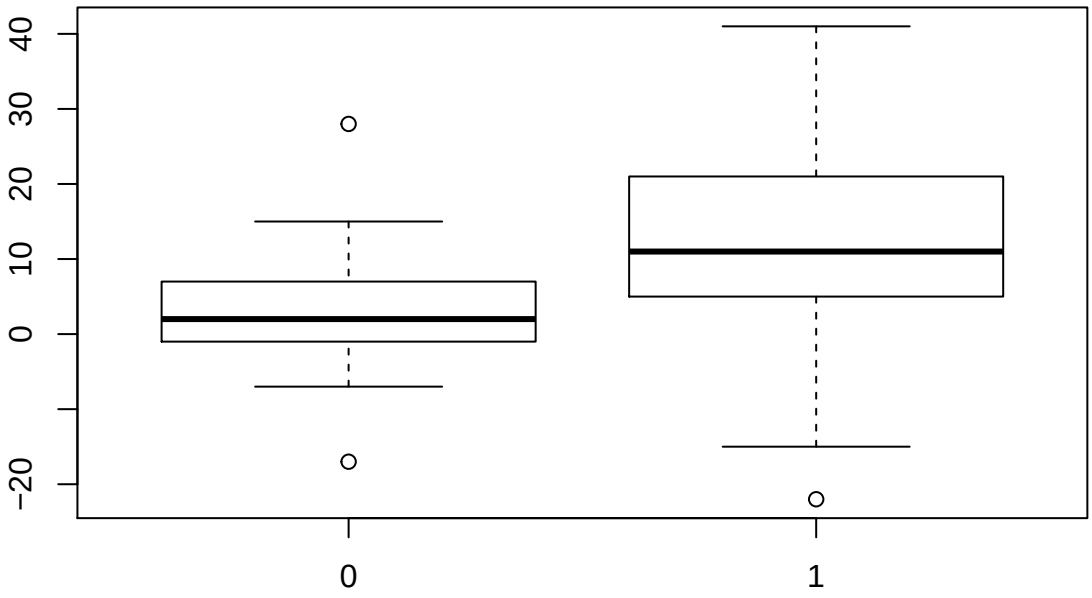

```
boxplot(improvelet~agecat)
```



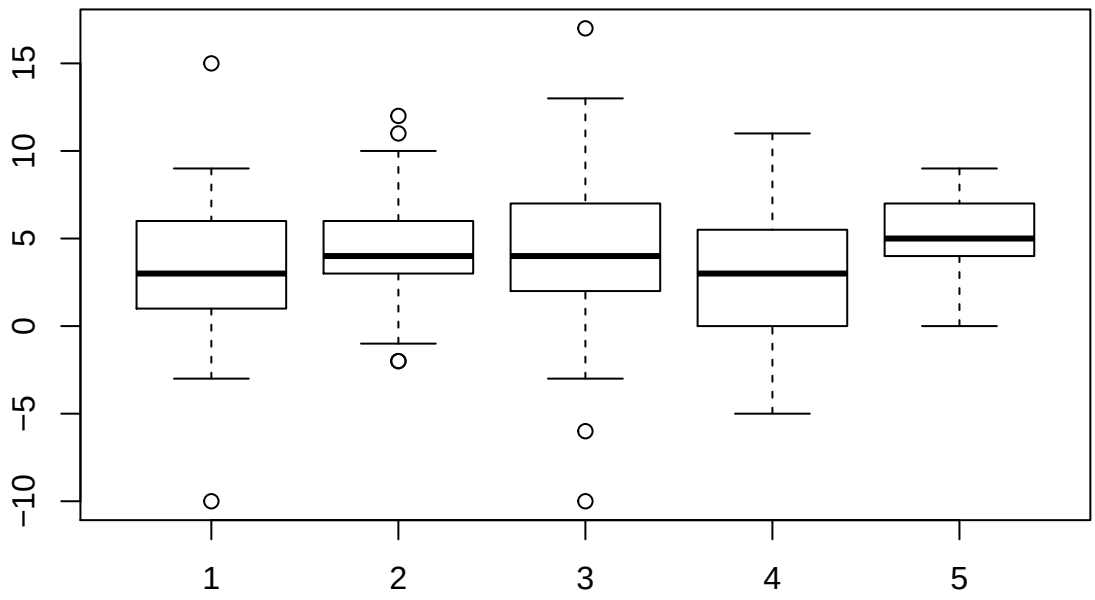

```
boxplot(improvelet~encour)
```



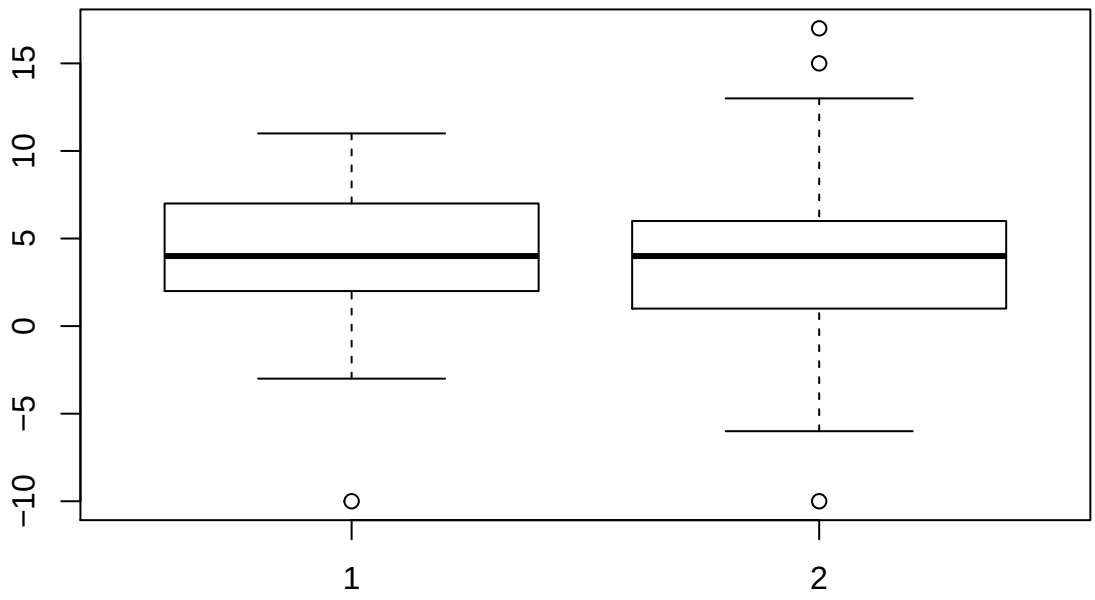

```
boxplot(improvelet~regular)
```



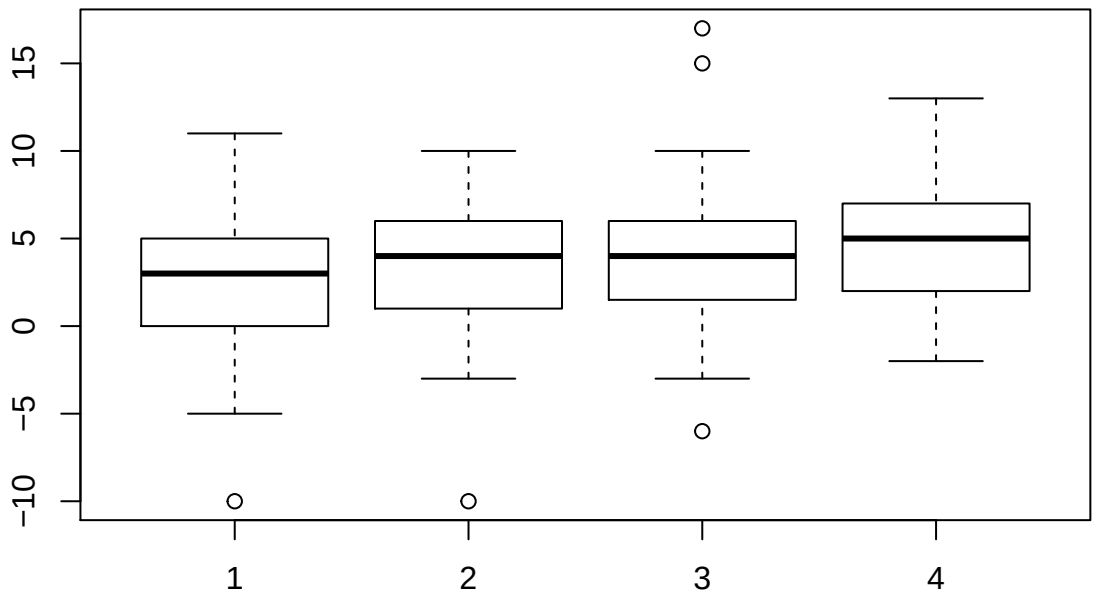

```
boxplot(improveform~site)
```



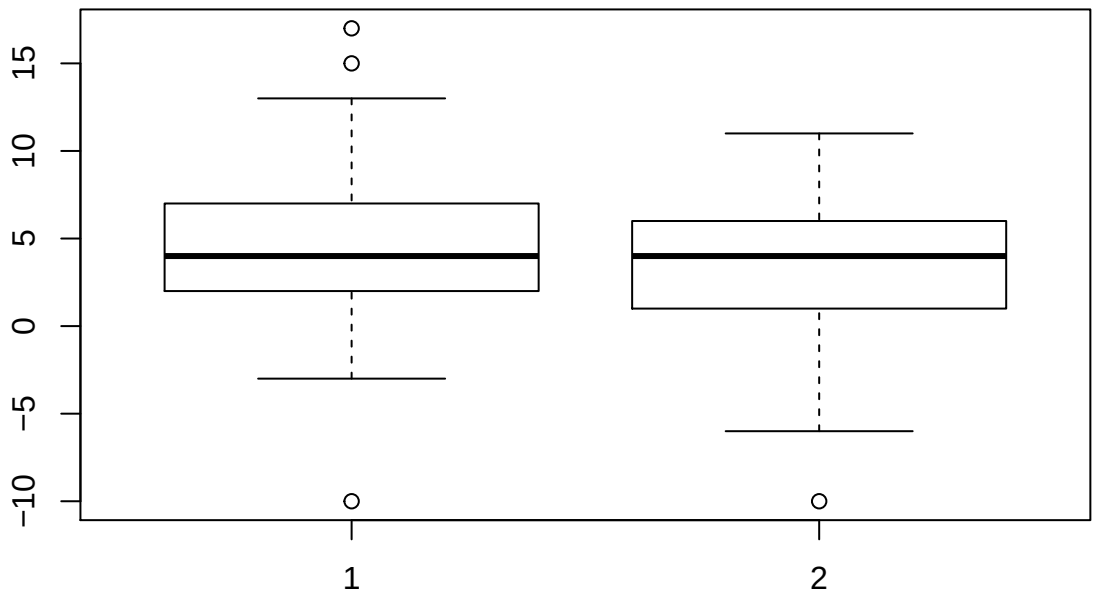

```
boxplot(improveform~sex)
```



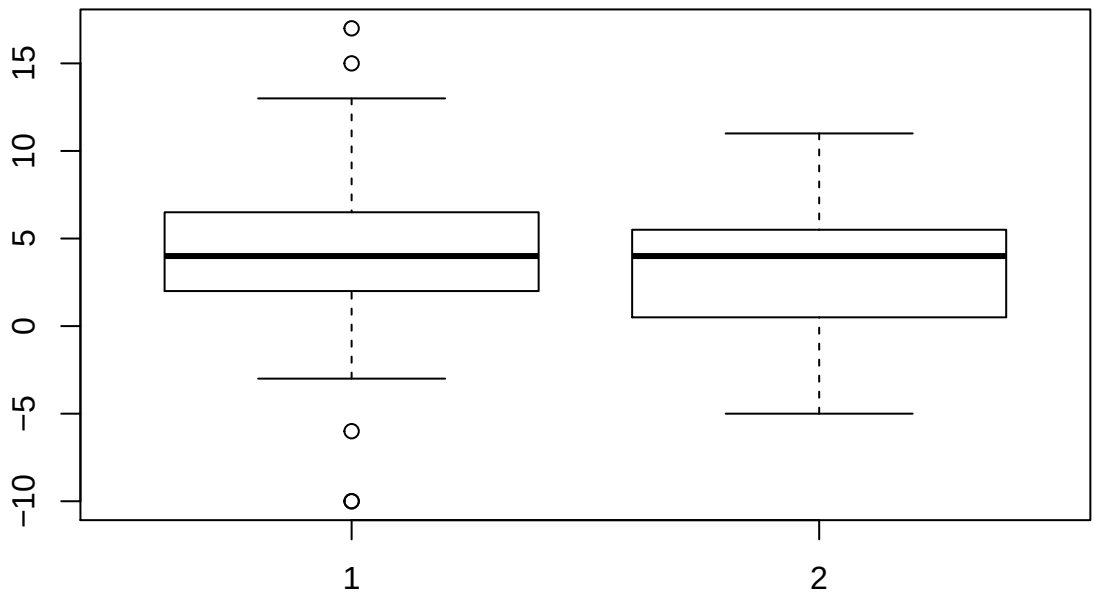

```
boxplot(improveform~viewcat)
```



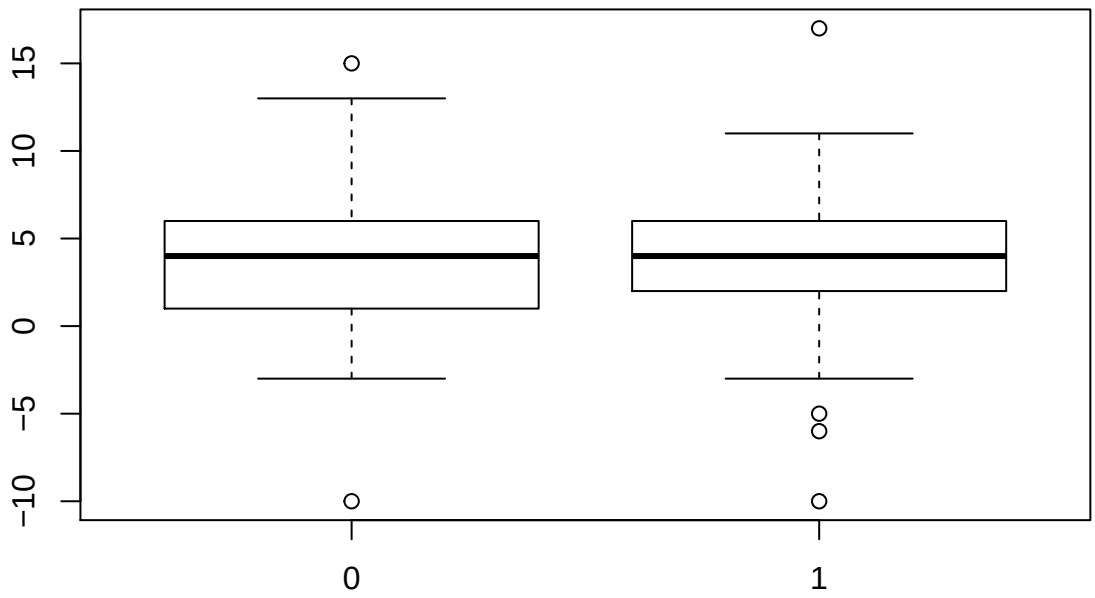

```
boxplot(improveform~setting)
```



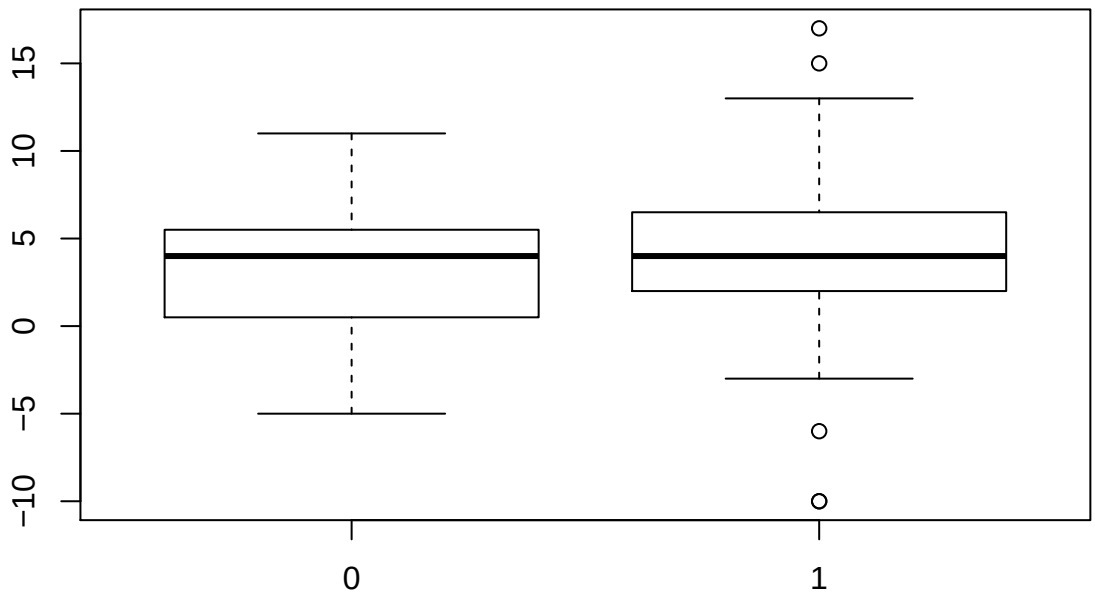

```
boxplot(improveform~viewenc)
```



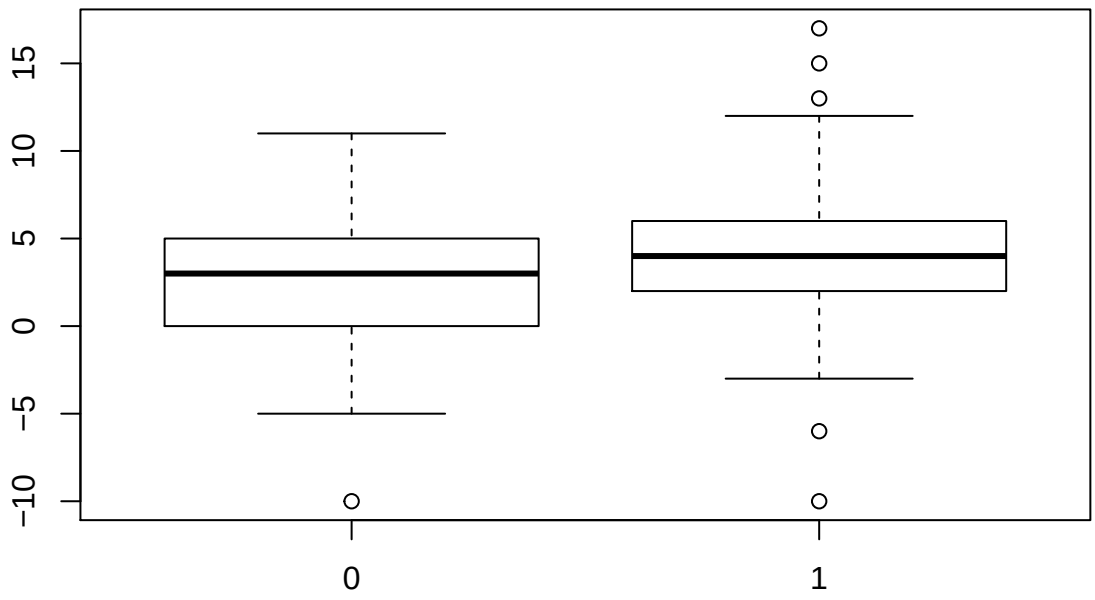

```
boxplot(improveform~agecat)
```




```
boxplot(improveform~encour)
```




```
boxplot(improveform~regular)
```




```
attach(sesame)
```

```
## The following objects are masked from SS:
##
##     age, agecat, encour, id, improvebody, improveclasf,
##     improveform, improvelet, improvenumb, improverelat, peabody,
##     postbody, postclasf, postform, postlet, postnumb, postrelat,
##     prebody, preclasf, preform, prelet, prenumb, prerelat,
##     regular, setting, sex, site, viewcat, viewenc
```

```
fit1=lm(improvenumb~sex+age++setting+viewenc+improveclasf+improvebody+improverelat+peabody+agecat+encou
summary(fit1)
```

```
##
## Call:
## lm(formula = improvenumb ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + prenumb)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -30.5908  -4.9256   0.5411   5.1912  19.2199
##
## Coefficients: (2 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -5.99254    7.26005  -0.825  0.41002
## sex          -0.41252    1.00956  -0.409  0.68321
```

```
## age           0.31786    0.14235   2.233  0.02655 *
## setting      -2.02893    1.16055  -1.748  0.08180 .
## viewenc      -0.52323    1.20103  -0.436  0.66351
## improveclasf  0.68216    0.12698   5.372 1.96e-07 ***
## improvebody   0.17509    0.10992   1.593  0.11260
## improverelat  0.54541    0.16780   3.250  0.00133 **
## peabody       0.04131    0.04529   0.912  0.36272
## agecat       -1.43906    1.62901  -0.883  0.37798
## encour             NA         NA      NA       NA
## regular       5.69209    1.73648   3.278  0.00121 **
## s1           -2.81290    2.26393  -1.242  0.21537
## s2            0.73833    2.26318   0.326  0.74455
## s3           -3.86603    2.18469  -1.770  0.07817 .
## s4           -3.77837    2.30706  -1.638  0.10289
## vc1                NA         NA      NA       NA
## vc2          -2.17541    1.45627  -1.494  0.13664
## vc3           0.37270    1.39058   0.268  0.78893
## prenumb      -0.30707    0.06660  -4.610 6.78e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.586 on 222 degrees of freedom
## Multiple R-squared:  0.4313, Adjusted R-squared:  0.3878
## F-statistic: 9.906 on 17 and 222 DF,  p-value: < 2.2e-16
```

```
MSE1=(summary(fit1)$sigma)^2
step(fit1, scale=MSE1, direction="backward")
```

```
## Start:  AIC=18
## improvenumb ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + prenumb
##
##
## Step:  AIC=18
## improvenumb ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc2 + vc3 + prenumb
##
##
## Step:  AIC=18
## improvenumb ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + regular +
##     s1 + s2 + s3 + s4 + vc2 + vc3 + prenumb
##
##                Df Sum of Sq   RSS     Cp
## - vc3           1      4.13 12779 16.072
## - s2            1      6.12 12781 16.106
## - sex           1      9.61 12785 16.167
## - viewenc       1     10.92 12786 16.190
## - agecat        1     44.91 12820 16.780
## - peabody       1     47.87 12823 16.832
## - s1            1     88.84 12864 17.544
## <none>                      12775 18.000
## - vc2           1    128.41 12903 18.232
```

```
## - improvebody   1    146.01 12921 18.537
## - s4            1    154.35 12929 18.682
## - setting       1    175.88 12951 19.056
## - s3            1    180.20 12955 19.131
## - age           1    286.92 13062 20.986
## - improverelat  1    607.97 13383 26.565
## - regular       1    618.32 13393 26.745
## - prenumb       1   1223.19 13998 37.256
## - improveclasf  1   1660.76 14436 44.860
##
## Step:  AIC=16.07
## improvenumb ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + regular +
##     s1 + s2 + s3 + s4 + vc2 + prenumb
##
##                Df Sum of Sq   RSS     Cp
## - s2            1      6.63 12786 14.187
## - sex           1      9.19 12788 14.232
## - viewenc       1     10.69 12790 14.258
## - agecat        1     45.29 12824 14.859
## - peabody       1     46.47 12826 14.879
## - s1            1     85.99 12865 15.566
## <none>                      12779 16.072
## - improvebody   1    143.73 12923 16.570
## - s4            1    150.75 12930 16.692
## - setting       1    174.07 12953 17.097
## - s3            1    176.75 12956 17.143
## - vc2           1    209.56 12989 17.713
## - age           1    287.06 13066 19.060
## - improverelat  1    605.26 13384 24.590
## - regular       1    830.21 13609 28.499
## - prenumb       1   1234.15 14013 35.518
## - improveclasf  1   1664.54 14444 42.998
##
## Step:  AIC=14.19
## improvenumb ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + regular +
##     s1 + s3 + s4 + vc2 + prenumb
##
##                Df Sum of Sq   RSS     Cp
## - sex           1      9.79 12796 12.357
## - viewenc       1     11.75 12798 12.391
## - agecat        1     44.01 12830 12.952
## - peabody       1     52.21 12838 13.094
## <none>                      12786 14.187
## - improvebody   1    138.40 12924 14.592
## - setting       1    202.61 12988 15.708
## - vc2           1    224.93 13011 16.096
## - s1            1    280.04 13066 17.053
## - age           1    280.49 13066 17.061
## - s4            1    357.50 13143 18.399
## - s3            1    443.55 13229 19.895
## - improverelat  1    617.39 13403 22.916
## - regular       1    902.72 13688 27.874
```

```
## - prenumb       1   1232.77 14019 33.610
## - improveclasf  1   1661.00 14447 41.051
##
## Step:  AIC=12.36
## improvenumb ~ age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + agecat + regular + s1 + s3 + s4 +
##     vc2 + prenumb
##
##                Df Sum of Sq   RSS     Cp
## - viewenc       1     11.60 12807 10.559
## - agecat        1     38.71 12834 11.030
## - peabody       1     49.24 12845 11.213
## <none>                      12796 12.357
## - improvebody   1    135.34 12931 12.709
## - setting       1    208.44 13004 13.979
## - vc2           1    225.04 13021 14.268
## - age           1    270.72 13066 15.062
## - s1            1    287.40 13083 15.352
## - s4            1    357.13 13153 16.563
## - s3            1    444.86 13240 18.088
## - improverelat  1    613.64 13409 21.021
## - regular       1    895.84 13691 25.925
## - prenumb       1   1223.10 14019 31.612
## - improveclasf  1   1700.09 14496 39.901
##
## Step:  AIC=10.56
## improvenumb ~ age + setting + improveclasf + improvebody + improverelat +
##     peabody + agecat + regular + s1 + s3 + s4 + vc2 + prenumb
##
##                Df Sum of Sq   RSS      Cp
## - agecat        1     37.11 12844  9.2036
## - peabody       1     56.70 12864  9.5440
## <none>                      12807 10.5587
## - improvebody   1    138.04 12945 10.9576
## - vc2           1    232.80 13040 12.6042
## - setting       1    247.79 13055 12.8648
## - age           1    265.40 13073 13.1707
## - s1            1    277.20 13084 13.3759
## - s4            1    353.92 13161 14.7089
## - s3            1    449.15 13256 16.3639
## - improverelat  1    613.60 13421 19.2217
## - regular       1    938.57 13746 24.8689
## - prenumb       1   1240.29 14048 30.1121
## - improveclasf  1   1688.61 14496 37.9028
##
## Step:  AIC=9.2
## improvenumb ~ age + setting + improveclasf + improvebody + improverelat +
##     peabody + regular + s1 + s3 + s4 + vc2 + prenumb
##
##                Df Sum of Sq   RSS      Cp
## - peabody       1     43.73 12888  7.9635
## <none>                      12844  9.2036
## - improvebody   1    134.88 12979  9.5474
## - vc2           1    231.27 13076 11.2226
```

```
## - setting       1    239.95 13084 11.3733
## - s1            1    280.72 13125 12.0818
## - age           1    305.33 13150 12.5095
## - s4            1    361.11 13205 13.4788
## - s3            1    465.53 13310 15.2934
## - improverelat  1    599.70 13444 17.6249
## - regular       1    926.83 13771 23.3096
## - prenumb       1   1204.67 14049 28.1379
## - improveclasf  1   1700.67 14545 36.7572
##
## Step:  AIC=7.96
## improvenumb ~ age + setting + improveclasf + improvebody + improverelat +
##     regular + s1 + s3 + s4 + vc2 + prenumb
##
##                Df Sum of Sq   RSS      Cp
## <none>                      12888  7.9635
## - improvebody   1    116.65 13005  7.9907
## - vc2           1    226.58 13115  9.9010
## - setting       1    231.26 13119  9.9823
## - age           1    324.21 13212 11.5975
## - s1            1    452.58 13341 13.8283
## - s4            1    457.41 13345 13.9122
## - improverelat  1    584.40 13472 16.1190
## - s3            1    708.33 13596 18.2726
## - regular       1    973.58 13862 22.8821
## - prenumb       1   1234.41 14122 27.4148
## - improveclasf  1   1777.87 14666 36.8588
```

```
##
## Call:
## lm(formula = improvenumb ~ age + setting + improveclasf + improvebody +
##     improverelat + regular + s1 + s3 + s4 + vc2 + prenumb)
##
## Coefficients:
##  (Intercept)           age       setting  improveclasf   improvebody
##       0.1008        0.2207       -2.1803        0.6964        0.1533
## improverelat       regular            s1            s3            s4
##       0.5272        5.8245       -3.8196       -4.9801       -4.6306
##          vc2       prenumb
##      -2.4408       -0.2762
```

```
none=lm(improvenumb~1)
step(none, scope=list(upper=fit1), scale=MSE1)
```

```
## Start:  AIC=152.39
## improvenumb ~ 1
##
##                Df Sum of Sq   RSS      Cp
## + improveclasf  1    5780.8 16685  53.937
## + improverelat  1    3157.1 19308  99.531
## + improvebody   1    1684.3 20781 125.125
## + regular       1    1449.8 21016 129.199
## + vc1           1    1449.8 21016 129.199
## + prenumb       1    1001.5 21464 136.990
## + s2            1     794.4 21671 140.589
```

```
## + s4            1     310.2 22155 149.004
## + vc3           1     267.9 22197 149.738
## + viewenc       1     196.2 22269 150.985
## + encour        1     196.2 22269 150.985
## + s1            1     136.1 22329 152.030
## <none>                      22465 152.394
## + vc2           1      39.7 22426 153.705
## + sex           1      11.9 22453 154.187
## + age           1      11.4 22454 154.197
## + peabody       1      10.4 22455 154.214
## + setting       1       7.0 22458 154.273
## + s3            1       6.8 22459 154.276
## + agecat        1       0.0 22465 154.394
##
## Step:  AIC=53.94
## improvenumb ~ improveclasf
##
##                 Df Sum of Sq   RSS      Cp
## + improverelat  1     802.6 15882  41.989
## + regular       1     650.8 16034  44.628
## + vc1           1     650.8 16034  44.628
## + prenumb       1     597.3 16087  45.557
## + improvebody   1     561.3 16123  46.183
## + s2            1     355.0 16329  49.767
## + vc3           1     162.3 16522  53.117
## <none>                      16685  53.937
## + s4            1      85.1 16599  54.458
## + s1            1      78.3 16606  54.577
## + setting       1      40.8 16644  55.228
## + vc2           1      19.9 16665  55.591
## + viewenc       1      18.3 16666  55.618
## + encour        1      18.3 16666  55.618
## + sex           1       3.2 16681  55.880
## + agecat        1       2.4 16682  55.895
## + s3            1       2.1 16682  55.901
## + peabody       1       1.6 16683  55.908
## + age           1       0.8 16684  55.923
## - improveclasf  1    5780.8 22465 152.394
##
## Step:  AIC=41.99
## improvenumb ~ improveclasf + improverelat
##
##                 Df Sum of Sq   RSS     Cp
## + regular       1     616.8 15265 33.270
## + vc1           1     616.8 15265 33.270
## + s2            1     484.2 15398 35.575
## + prenumb       1     340.8 15541 38.066
## + improvebody   1     334.7 15547 38.172
## + vc3           1     195.1 15687 40.599
## + s4            1     184.3 15698 40.786
## <none>                      15882 41.989
## + setting       1      78.1 15804 42.632
## + s1            1      39.5 15842 43.302
## + age           1      38.1 15844 43.326
```

```
## + s3            1      29.3 15852 43.479
## + peabody       1      25.5 15856 43.545
## + agecat        1      20.6 15861 43.631
## + vc2           1      13.6 15868 43.753
## + viewenc       1       8.9 15873 43.835
## + encour        1       8.9 15873 43.835
## + sex           1       2.7 15879 43.942
## - improverelat  1     802.6 16685 53.937
## - improveclasf  1    3426.3 19308 99.531
##
## Step:  AIC=33.27
## improvenumb ~ improveclasf + improverelat + regular
##
##                Df Sum of Sq   RSS     Cp
## + prenumb       1    607.45 14658 24.714
## + s2            1    313.57 14951 29.821
## + improvebody   1    307.87 14957 29.920
## + setting       1    153.45 15112 32.603
## + vc2           1    151.40 15114 32.639
## <none>                      15265 33.270
## + s1            1     84.44 15181 33.802
## + viewenc       1     60.00 15205 34.227
## + encour        1     60.00 15205 34.227
## + s3            1     46.09 15219 34.469
## + vc3           1     39.38 15226 34.586
## + age           1     33.70 15231 34.684
## + s4            1     29.21 15236 34.762
## + agecat        1     14.51 15250 35.018
## + peabody       1      0.02 15265 35.269
## + sex           1      0.01 15265 35.270
## - regular       1    616.82 15882 41.989
## - improverelat  1    768.69 16034 44.628
## - improveclasf  1   2941.52 18207 82.387
##
## Step:  AIC=24.71
## improvenumb ~ improveclasf + improverelat + regular + prenumb
##
##                Df Sum of Sq   RSS     Cp
## + s2            1    581.31 14076 16.612
## + vc2           1    305.98 14352 21.396
## + age           1    303.42 14354 21.441
## + peabody       1    269.28 14388 22.034
## + setting       1    264.67 14393 22.114
## + s3            1    171.59 14486 23.732
## + improvebody   1    119.78 14538 24.632
## + agecat        1    119.63 14538 24.635
## <none>                      14658 24.714
## + viewenc       1     84.02 14574 25.254
## + encour        1     84.02 14574 25.254
## + s1            1     72.50 14585 25.454
## + vc3           1     38.27 14619 26.049
## + s4            1     31.36 14626 26.169
## + sex           1      0.06 14658 26.713
## - improverelat  1    442.54 15100 30.404
```

```
## - prenumb       1    607.45 15265 33.270
## - regular       1    883.47 15541 38.066
## - improveclasf  1   2853.77 17511 72.305
##
## Step:  AIC=16.61
## improvenumb ~ improveclasf + improverelat + regular + prenumb +
##     s2
##
##                 Df Sum of Sq   RSS     Cp
## + age            1    467.58 13609 10.487
## + setting        1    244.23 13832 14.368
## + vc2            1    218.26 13858 14.819
## + improvebody    1    163.56 13913 15.770
## + agecat         1    163.49 13913 15.771
## <none>                       14076 16.612
## + viewenc        1     60.79 14016 17.556
## + encour         1     60.79 14016 17.556
## + vc3            1     43.98 14032 17.848
## + peabody        1     43.30 14033 17.860
## + s3             1     38.77 14038 17.938
## + s4             1      1.28 14075 18.590
## + sex            1      1.05 14075 18.594
## + s1             1      0.25 14076 18.608
## - improverelat   1    500.39 14577 23.308
## - s2             1    581.31 14658 24.714
## - regular        1    687.46 14764 26.558
## - prenumb        1    875.19 14951 29.821
## - improveclasf   1   2445.84 16522 57.115
##
## Step:  AIC=10.49
## improvenumb ~ improveclasf + improverelat + regular + prenumb +
##     s2 + age
##
##                 Df Sum of Sq   RSS      Cp
## + vc2            1    203.84 13405  8.9444
## + improvebody    1    158.50 13450  9.7323
## + setting        1    124.04 13485 10.3311
## <none>                       13609 10.4866
## + s3             1     98.75 13510 10.7706
## + viewenc        1     60.65 13548 11.4326
## + encour         1     60.65 13548 11.4326
## + vc3            1     46.57 13562 11.6773
## + agecat         1     32.19 13576 11.9272
## + s1             1     25.60 13583 12.0418
## + peabody        1     24.89 13584 12.0540
## + s4             1      5.18 13604 12.3966
## + sex            1      1.13 13608 12.4669
## - age            1    467.58 14076 16.6120
## - improverelat   1    597.02 14206 18.8614
## - s2             1    745.46 14354 21.4410
## - regular        1    757.48 14366 21.6498
## - prenumb        1   1298.17 14907 31.0458
## - improveclasf   1   2314.58 15923 48.7086
##
```

```
## Step:  AIC=8.94
## improvenumb ~ improveclasf + improverelat + regular + prenumb +
##     s2 + age + vc2
##
##                Df Sum of Sq   RSS      Cp
## + improvebody   1    132.74 13272  8.6376
## + setting       1    128.38 13276  8.7135
## + s3            1    122.54 13282  8.8149
## <none>                      13405  8.9444
## + viewenc       1     50.51 13354 10.0666
## + encour        1     50.51 13354 10.0666
## + peabody       1     37.22 13368 10.2976
## + agecat        1     31.63 13373 10.3947
## - vc2           1    203.84 13609 10.4866
## + s1            1     19.98 13385 10.5971
## + sex           1      1.29 13404 10.9219
## + s4            1      1.12 13404 10.9248
## + vc3           1      0.55 13404 10.9348
## - age           1    453.16 13858 14.8192
## - improverelat  1    528.92 13934 16.1357
## - s2            1    645.54 14050 18.1624
## - regular       1    951.19 14356 23.4738
## - prenumb       1   1419.95 14825 31.6198
## - improveclasf  1   2239.14 15644 45.8554
##
## Step:  AIC=8.64
## improvenumb ~ improveclasf + improverelat + regular + prenumb +
##     s2 + age + vc2 + improvebody
##
##                Df Sum of Sq   RSS      Cp
## + setting       1    151.26 13121  8.0090
## <none>                      13272  8.6376
## + s3            1    112.97 13159  8.6745
## - improvebody   1    132.74 13405  8.9444
## + viewenc       1     52.27 13220  9.7292
## + encour        1     52.27 13220  9.7292
## - vc2           1    178.08 13450  9.7323
## + peabody       1     49.15 13223  9.7834
## + s1            1     35.68 13236 10.0175
## + agecat        1     32.47 13240 10.0733
## + s4            1      4.69 13267 10.5561
## + sex           1      2.28 13270 10.5980
## + vc3           1      0.00 13272 10.6376
## - age           1    449.47 13722 14.4484
## - improverelat  1    455.88 13728 14.5597
## - s2            1    689.63 13962 18.6218
## - regular       1    847.58 14120 21.3666
## - prenumb       1   1126.71 14399 26.2171
## - improveclasf  1   2046.21 15318 42.1960
##
## Step:  AIC=8.01
## improvenumb ~ improveclasf + improverelat + regular + prenumb +
##     s2 + age + vc2 + improvebody + setting
##
```

```
##                Df Sum of Sq   RSS      Cp
## <none>                      13121  8.0090
## - setting       1    151.26 13272  8.6376
## + s3            1     75.40 13045  8.6988
## - improvebody   1    155.63 13276  8.7135
## + peabody       1     71.26 13050  8.7706
## - vc2           1    180.45 13301  9.1448
## + agecat        1     35.52 13085  9.3917
## + viewenc       1     16.27 13105  9.7263
## + encour        1     16.27 13105  9.7263
## + s4            1     14.15 13107  9.7631
## + s1            1     10.24 13111  9.8311
## + sex           1      0.70 13120  9.9969
## + vc3           1      0.00 13121 10.0090
## - age           1    322.00 13443 11.6047
## - improverelat  1    461.21 13582 14.0238
## - s2            1    650.20 13771 17.3081
## - regular       1    935.39 14056 22.2639
## - prenumb       1   1137.28 14258 25.7723
## - improveclasf  1   2035.69 15156 41.3845
```

```
##
## Call:
## lm(formula = improvenumb ~ improveclasf + improverelat + regular +
##     prenumb + s2 + age + vc2 + improvebody + setting)
##
## Coefficients:
##  (Intercept)  improveclasf  improverelat       regular       prenumb
##      -4.2240        0.7350        0.4572        5.4536       -0.2574
##           s2           age           vc2   improvebody       setting
##       4.2616        0.2145       -2.1799        0.1763       -1.7083
```

```
fit2=lm(improvelet~sex+age++setting+viewenc+improveclasf+improvebody+improverelat+peabody+agecat+encour
summary(fit2)
```

```
##
## Call:
## lm(formula = improvelet ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + prelet)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -24.7005  -4.9682  -0.3181   4.4473  21.1414
##
## Coefficients: (2 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -7.23623    7.62041  -0.950 0.343356
## sex          -0.74258    1.08949  -0.682 0.496214
## age           0.20188    0.14921   1.353 0.177445
## setting      -0.75410    1.25952  -0.599 0.549971
## viewenc       1.76889    1.29865   1.362 0.174546
## improveclasf  0.46650    0.13686   3.409 0.000775 ***
## improvebody   0.23854    0.11728   2.034 0.043143 *
## improverelat  0.18170    0.18118   1.003 0.317010
```

```
## peabody       0.07693    0.04577   1.681 0.094224 .
## agecat        1.12824    1.75464   0.643 0.520888
## encour             NA         NA      NA       NA
## regular       9.15020    1.85926   4.921 1.67e-06 ***
## s1            0.65346    2.43857   0.268 0.788973
## s2            6.25533    2.45344   2.550 0.011458 *
## s3           -5.26395    2.36766  -2.223 0.027205 *
## s4           -1.23288    2.50203  -0.493 0.622674
## vc1                NA         NA      NA       NA
## vc2          -5.52391    1.55803  -3.545 0.000478 ***
## vc3           0.45904    1.50363   0.305 0.760433
## prelet       -0.34609    0.07312  -4.733 3.94e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 8.195 on 222 degrees of freedom
## Multiple R-squared:  0.4998, Adjusted R-squared:  0.4615
## F-statistic: 13.05 on 17 and 222 DF,  p-value: < 2.2e-16
```

```
MSE2=(summary(fit2)$sigma)^2
step(fit2, scale=MSE2, direction="backward")
```

```
## Start:  AIC=18
## improvelet ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + prelet
##
##
## Step:  AIC=18
## improvelet ~ sex + age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + agecat + encour + regular + s1 +
##     s2 + s3 + s4 + vc2 + vc3 + prelet
##
##
## Step:  AIC=18
## improvelet ~ sex + age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + agecat + regular + s1 + s2 + s3 +
##     s4 + vc2 + vc3 + prelet
##
##                Df Sum of Sq   RSS     Cp
## - s1            1      4.82 14915 16.072
## - vc3           1      6.26 14917 16.093
## - s4            1     16.31 14927 16.243
## - setting       1     24.08 14934 16.358
## - agecat        1     27.77 14938 16.413
## - sex           1     31.20 14942 16.465
## - improverelat  1     67.55 14978 17.006
## - age           1    122.94 15033 17.831
## - viewenc       1    124.61 15035 17.855
## <none>                      14910 18.000
## - peabody       1    189.72 15100 18.825
## - improvebody   1    277.86 15188 20.137
## - s3            1    331.99 15242 20.943
## - s2            1    436.60 15347 22.501
## - improveclasf  1    780.36 15691 27.619
```

```
## - vc2           1    844.26 15755 28.570
## - prelet        1   1504.59 16415 38.402
## - regular       1   1626.72 16537 40.220
##
## Step:  AIC=16.07
## improvelet ~ sex + age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + agecat + regular + s2 + s3 + s4 +
##     vc2 + vc3 + prelet
##
##                Df Sum of Sq   RSS     Cp
## - vc3           1      7.38 14922 14.182
## - agecat        1     28.57 14944 14.497
## - sex           1     31.12 14946 14.535
## - setting       1     31.84 14947 14.546
## - s4            1     68.21 14983 15.087
## - improverelat  1     70.18 14985 15.117
## - age           1    119.52 15035 15.851
## - viewenc       1    120.38 15036 15.864
## <none>                      14915 16.072
## - peabody       1    184.93 15100 16.825
## - improvebody   1    273.31 15188 18.141
## - improveclasf  1    776.03 15691 25.626
## - s2            1    827.84 15743 26.398
## - vc2           1    848.04 15763 26.698
## - s3            1   1003.06 15918 29.006
## - prelet        1   1504.53 16420 36.473
## - regular       1   1708.32 16623 39.507
##
## Step:  AIC=14.18
## improvelet ~ sex + age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + agecat + regular + s2 + s3 + s4 +
##     vc2 + prelet
##
##                Df Sum of Sq   RSS     Cp
## - agecat        1     28.24 14951 12.602
## - sex           1     30.12 14953 12.630
## - setting       1     31.54 14954 12.651
## - improverelat  1     65.77 14988 13.161
## - s4            1     66.32 14989 13.169
## - age           1    119.03 15042 13.954
## - viewenc       1    120.26 15043 13.972
## <none>                      14922 14.182
## - peabody       1    180.19 15103 14.864
## - improvebody   1    268.52 15191 16.180
## - improveclasf  1    778.31 15701 23.770
## - s2            1    822.82 15745 24.433
## - s3            1    999.59 15922 27.065
## - vc2           1   1287.94 16210 31.358
## - prelet        1   1525.78 16448 34.899
## - regular       1   2343.60 17266 47.076
##
## Step:  AIC=12.6
## improvelet ~ sex + age + setting + viewenc + improveclasf + improvebody +
##     improverelat + peabody + regular + s2 + s3 + s4 + vc2 + prelet
```

```
##
##                Df Sum of Sq   RSS     Cp
## - setting       1     33.43 14984 11.100
## - sex           1     40.51 14991 11.205
## - s4            1     64.92 15016 11.569
## - improverelat  1     71.94 15023 11.673
## - viewenc       1    113.82 15065 12.297
## <none>                      14951 12.602
## - peabody       1    203.47 15154 13.632
## - improvebody   1    277.33 15228 14.731
## - age           1    503.44 15454 18.098
## - improveclasf  1    770.29 15721 22.071
## - s2            1    824.45 15775 22.877
## - s3            1    982.17 15933 25.226
## - vc2           1   1283.27 16234 29.709
## - prelet        1   1603.39 16554 34.475
## - regular       1   2367.71 17319 45.855
##
## Step:  AIC=11.1
## improvelet ~ sex + age + viewenc + improveclasf + improvebody +
##     improverelat + peabody + regular + s2 + s3 + s4 + vc2 + prelet
##
##                Df Sum of Sq   RSS      Cp
## - sex           1     44.14 15028  9.7571
## - s4            1     57.50 15042  9.9560
## - improverelat  1     69.57 15054 10.1357
## - viewenc       1     90.32 15074 10.4446
## <none>                      14984 11.0998
## - peabody       1    181.56 15166 11.8031
## - improvebody   1    259.85 15244 12.9688
## - age           1    612.76 15597 18.2232
## - improveclasf  1    786.25 15770 20.8064
## - s2            1    864.59 15849 21.9728
## - s3            1   1026.25 16010 24.3796
## - vc2           1   1277.04 16261 28.1138
## - prelet        1   1573.21 16557 32.5234
## - regular       1   2373.84 17358 44.4441
##
## Step:  AIC=9.76
## improvelet ~ age + viewenc + improveclasf + improvebody + improverelat +
##     peabody + regular + s2 + s3 + s4 + vc2 + prelet
##
##                Df Sum of Sq   RSS      Cp
## - s4            1     51.51 15080  8.5241
## - improverelat  1     66.56 15095  8.7481
## - viewenc       1     90.11 15118  9.0987
## <none>                      15028  9.7571
## - peabody       1    172.91 15201 10.3315
## - improvebody   1    249.92 15278 11.4781
## - age           1    586.89 15615 16.4954
## - improveclasf  1    827.46 15856 20.0772
## - s2            1    900.95 15929 21.1714
## - s3            1   1008.47 16037 22.7723
## - vc2           1   1277.55 16306 26.7785
```

```
## - prelet        1   1550.63 16579 30.8444
## - regular       1   2349.76 17378 42.7428
##
## Step:  AIC=8.52
## improvelet ~ age + viewenc + improveclasf + improvebody + improverelat +
##     peabody + regular + s2 + s3 + vc2 + prelet
##
##                Df Sum of Sq   RSS      Cp
## - improverelat  1     46.39 15126  7.2149
## - viewenc       1     87.78 15168  7.8310
## <none>                      15080  8.5241
## - peabody       1    166.48 15246  9.0029
## - improvebody   1    230.96 15311  9.9628
## - age           1    549.83 15630 14.7105
## - improveclasf  1    907.44 15987 20.0349
## - s3            1   1001.38 16081 21.4336
## - s2            1   1115.03 16195 23.1259
## - vc2           1   1316.04 16396 26.1187
## - prelet        1   1504.18 16584 28.9199
## - regular       1   2759.50 17839 47.6103
##
## Step:  AIC=7.21
## improvelet ~ age + viewenc + improveclasf + improvebody + peabody +
##     regular + s2 + s3 + vc2 + prelet
##
##                Df Sum of Sq   RSS      Cp
## - viewenc       1     88.40 15215  6.5310
## <none>                      15126  7.2149
## - peabody       1    150.83 15277  7.4606
## - improvebody   1    265.96 15392  9.1748
## - age           1    516.50 15643 12.9051
## - s3            1    972.40 16099 19.6930
## - s2            1   1110.07 16236 21.7428
## - improveclasf  1   1220.60 16347 23.3884
## - vc2           1   1350.30 16477 25.3195
## - prelet        1   1499.82 16626 27.5457
## - regular       1   2803.19 17929 46.9517
##
## Step:  AIC=6.53
## improvelet ~ age + improveclasf + improvebody + peabody + regular +
##     s2 + s3 + vc2 + prelet
##
##                Df Sum of Sq   RSS      Cp
## <none>                      15215  6.5310
## - peabody       1     143.3 15358  6.6642
## - improvebody   1     264.9 15480  8.4746
## - age           1     524.2 15739 12.3365
## - s3            1     909.8 16124 18.0768
## - s2            1    1121.5 16336 21.2292
## - improveclasf  1    1266.7 16481 23.3915
## - vc2           1    1318.5 16533 24.1616
## - prelet        1    1585.1 16800 28.1310
## - regular       1    3690.4 18905 59.4775
```

```
##
## Call:
## lm(formula = improvelet ~ age + improveclasf + improvebody +
##     peabody + regular + s2 + s3 + vc2 + prelet)
##
## Coefficients:
##  (Intercept)           age  improveclasf   improvebody       peabody
##     -9.75733       0.25973       0.54348       0.22414       0.06387
##      regular            s2            s3           vc2        prelet
##     10.63175       6.38403      -4.87814      -5.84246      -0.34504
```

```
none=lm(improvelet~1)
step(none, scope=list(upper=fit2), scale=MSE2)
```

```
## Start:  AIC=205.84
## improvelet ~ 1
##
##                Df Sum of Sq   RSS     Cp
## + s2            1    5497.4 24312 125.99
## + regular       1    4826.4 24983 135.98
## + vc1           1    4826.4 24983 135.98
## + improveclasf  1    3977.5 25832 148.62
## + peabody       1    2372.0 27438 172.52
## + vc3           1    1536.4 28273 184.96
## + s3            1    1467.8 28342 185.98
## + viewenc       1    1192.2 28618 190.09
## + encour        1    1192.2 28618 190.09
## + s4            1     814.7 28995 195.71
## + improverelat  1     672.7 29137 197.82
## + improvebody   1     654.6 29155 198.09
## + vc2           1     481.8 29328 200.66
## + agecat        1     288.6 29521 203.54
## + prelet        1     286.8 29523 203.57
## <none>                      29810 205.84
## + age           1      82.4 29727 206.61
## + sex           1      22.2 29788 207.51
## + s1            1      20.3 29790 207.54
## + setting       1      13.6 29796 207.64
##
## Step:  AIC=125.99
## improvelet ~ s2
##
##                Df Sum of Sq   RSS      Cp
## + regular       1    3118.7 21194  81.554
## + vc1           1    3118.7 21194  81.554
## + improveclasf  1    2941.6 21371  84.189
## + vc3           1    1250.9 23062 109.364
## + improvebody   1    1163.3 23149 110.667
## + viewenc       1    1073.1 23239 112.011
## + encour        1    1073.1 23239 112.011
## + improverelat  1     872.0 23440 115.005
## + prelet        1     678.6 23634 117.884
## + s1            1     393.6 23919 122.127
## + agecat        1     271.2 24041 123.950
## + vc2           1     244.7 24068 124.344
```

```
## + s3            1     217.7 24095 124.747
## + peabody       1     157.9 24155 125.637
## <none>                      24312 125.988
## + age           1     130.3 24182 126.047
## + s4            1      99.7 24213 126.503
## + setting       1      40.2 24272 127.389
## + sex           1       1.6 24311 127.964
## - s2            1    5497.4 29810 205.839
##
## Step:  AIC=81.55
## improvelet ~ s2 + regular
##
##                Df Sum of Sq   RSS      Cp
## + improveclasf  1    2153.9 19040  51.484
## + vc2           1    1334.9 19859  63.678
## + prelet        1     914.8 20279  69.933
## + improvebody   1     826.5 20367  71.249
## + improverelat  1     576.6 20617  74.969
## + s3            1     490.7 20703  76.248
## + vc3           1     338.4 20855  78.515
## + agecat        1     233.2 20961  80.082
## <none>                      21194  81.554
## + age           1     121.6 21072  81.743
## + viewenc       1     102.7 21091  82.024
## + encour        1     102.7 21091  82.024
## + s1            1     100.4 21093  82.059
## + s4            1      61.7 21132  82.636
## + peabody       1      42.0 21152  82.929
## + sex           1      25.7 21168  83.171
## + setting       1       5.8 21188  83.467
## - regular       1    3118.7 24312 125.988
## - s2            1    3789.7 24983 135.979
##
## Step:  AIC=51.48
## improvelet ~ s2 + regular + improveclasf
##
##                Df Sum of Sq   RSS     Cp
## + vc2           1    1117.6 17922 36.844
## + prelet        1     654.5 18385 43.739
## + s3            1     507.9 18532 45.922
## + vc3           1     350.0 18690 48.274
## + improvebody   1     323.1 18717 48.674
## + agecat        1     273.3 18767 49.416
## + age           1     184.1 18856 50.743
## <none>                      19040 51.484
## + s1            1     125.2 18915 51.621
## + s4            1      92.8 18947 52.102
## + peabody       1      56.5 18983 52.644
## + viewenc       1      47.3 18993 52.781
## + encour        1      47.3 18993 52.781
## + improverelat  1      36.5 19003 52.941
## + setting       1      15.0 19025 53.260
## + sex           1       2.5 19037 53.447
## - improveclasf  1    2153.9 21194 81.554
```

```
## - regular       1    2330.9 21371 84.189
## - s2            1    3239.3 22279 97.714
##
## Step:  AIC=36.84
## improvelet ~ s2 + regular + improveclasf + vc2
##
##                Df Sum of Sq   RSS     Cp
## + prelet        1     842.6 17080 26.298
## + s3            1     593.3 17329 30.011
## + improvebody   1     277.9 17644 34.707
## + agecat        1     216.3 17706 35.624
## + s4            1     142.2 17780 36.727
## <none>                      17922 36.844
## + age           1     119.0 17803 37.072
## + s1            1      92.8 17829 37.462
## + viewenc       1      74.8 17847 37.730
## + encour        1      74.8 17847 37.730
## + peabody       1      51.1 17871 38.083
## + improverelat  1      17.6 17905 38.582
## + setting       1      12.3 17910 38.662
## + vc3           1       3.7 17919 38.789
## + sex           1       3.5 17919 38.792
## - vc2           1    1117.6 19040 51.484
## - improveclasf  1    1936.6 19859 63.678
## - s2            1    2618.5 20541 73.831
## - regular       1    3226.4 21149 82.882
##
## Step:  AIC=26.3
## improvelet ~ s2 + regular + improveclasf + vc2 + prelet
##
##                Df Sum of Sq   RSS     Cp
## + s3            1     891.3 16188 15.027
## + age           1     464.4 16615 21.384
## + agecat        1     433.0 16647 21.851
## + peabody       1     355.7 16724 23.002
## + s1            1     198.0 16882 25.350
## + improvebody   1     141.0 16939 26.200
## <none>                      17080 26.298
## + s4            1     119.7 16960 26.516
## + setting       1      86.6 16993 27.010
## + viewenc       1      22.2 17057 27.969
## + encour        1      22.2 17057 27.969
## + sex           1       3.7 17076 28.244
## + vc3           1       1.0 17079 28.284
## + improverelat  1       0.7 17079 28.289
## - prelet        1     842.6 17922 36.844
## - vc2           1    1305.7 18385 43.739
## - improveclasf  1    1643.0 18723 48.761
## - s2            1    2891.3 19971 67.347
## - regular       1    3577.4 20657 77.562
##
## Step:  AIC=15.03
## improvelet ~ s2 + regular + improveclasf + vc2 + prelet + s3
##
```

```
##                 Df Sum of Sq   RSS      Cp
## + age            1     622.2 15566  7.7641
## + agecat         1     585.9 15602  8.3044
## + peabody        1     221.1 15967 13.7351
## + improvebody    1     144.8 16043 14.8711
## <none>                       16188 15.0273
## + viewenc        1      86.1 16102 15.7451
## + encour         1      86.1 16102 15.7451
## + setting        1      32.5 16156 16.5428
## + improverelat   1      11.1 16177 16.8620
## + sex            1       6.2 16182 16.9352
## + s1             1       4.6 16184 16.9590
## + vc3            1       0.7 16188 17.0167
## + s4             1       0.7 16188 17.0172
## - s3             1     891.3 17080 26.2984
## - prelet         1    1140.7 17329 30.0112
## - vc2            1    1457.0 17645 34.7207
## - improveclasf   1    1607.0 17795 36.9540
## - s2             1    1638.1 17826 37.4176
## - regular        1    4067.9 20256 73.5938
##
## Step:  AIC=7.76
## improvelet ~ s2 + regular + improveclasf + vc2 + prelet + s3 +
##     age
##
##                 Df Sum of Sq   RSS      Cp
## + improvebody    1     208.2 15358  6.6642
## <none>                       15566  7.7641
## + peabody        1      86.6 15480  8.4746
## + viewenc        1      81.4 15485  8.5516
## + encour         1      81.4 15485  8.5516
## + improverelat   1      61.3 15505  8.8520
## + agecat         1      60.9 15505  8.8577
## + sex            1      24.2 15542  9.4032
## + s4             1      12.0 15554  9.5847
## + s1             1       1.0 15565  9.7485
## + vc3            1       0.3 15566  9.7602
## + setting        1       0.0 15566  9.7637
## - age            1     622.2 16188 15.0273
## - s3             1    1049.1 16615 21.3838
## - vc2            1    1372.9 16939 26.2052
## - prelet         1    1618.7 17185 29.8648
## - improveclasf   1    1653.5 17220 30.3830
## - s2             1    1705.2 17271 31.1535
## - regular        1    4111.1 19677 66.9743
##
## Step:  AIC=6.66
## improvelet ~ s2 + regular + improveclasf + vc2 + prelet + s3 +
##     age + improvebody
##
##                 Df Sum of Sq   RSS      Cp
## + peabody        1     143.3 15215  6.5310
## <none>                       15358  6.6642
## + viewenc        1      80.8 15277  7.4606
```

```
## + encour        1      80.8 15277  7.4606
## - improvebody   1     208.2 15566  7.7641
## + agecat        1      54.7 15303  7.8493
## + improverelat  1      31.6 15326  8.1943
## + sex           1      30.1 15328  8.2160
## + s4            1      27.8 15330  8.2507
## + s1            1      14.8 15343  8.4437
## + setting       1       0.8 15357  8.6521
## + vc3           1       0.2 15358  8.6611
## - age           1     685.5 16043 14.8711
## - s3            1    1063.4 16421 20.4977
## - vc2           1    1303.8 16662 24.0772
## - improveclasf  1    1324.4 16682 24.3829
## - prelet        1    1448.3 16806 26.2276
## - s2            1    1840.1 17198 32.0609
## - regular       1    3911.9 19270 62.9086
##
## Step:  AIC=6.53
## improvelet ~ s2 + regular + improveclasf + vc2 + prelet + s3 +
##     age + improvebody + peabody
##
##                Df Sum of Sq   RSS      Cp
## <none>                      15215  6.5310
## - peabody       1     143.3 15358  6.6642
## + viewenc       1      88.4 15126  7.2149
## + encour        1      88.4 15126  7.2149
## + improverelat  1      47.0 15168  7.8310
## + sex           1      36.8 15178  7.9828
## + agecat        1      36.3 15178  7.9908
## + s1            1      31.4 15183  8.0627
## + s4            1      29.5 15185  8.0922
## + setting       1       7.9 15207  8.4140
## - improvebody   1     264.9 15480  8.4746
## + vc3           1       1.6 15213  8.5070
## - age           1     524.2 15739 12.3365
## - s3            1     909.8 16124 18.0768
## - s2            1    1121.5 16336 21.2292
## - improveclasf  1    1266.7 16481 23.3915
## - vc2           1    1318.5 16533 24.1616
## - prelet        1    1585.1 16800 28.1310
## - regular       1    3690.4 18905 59.4775
##
## Call:
## lm(formula = improvelet ~ s2 + regular + improveclasf + vc2 +
##     prelet + s3 + age + improvebody + peabody)
##
## Coefficients:
##  (Intercept)            s2       regular  improveclasf           vc2
##     -9.75733       6.38403      10.63175       0.54348      -5.84246
##       prelet            s3           age   improvebody       peabody
##     -0.34504      -4.87814       0.25973       0.22414       0.06387
```

```
fit3=lm(improveform~sex+age++setting+viewenc+improveclasf+improvebody+improverelat+peabody+agecat+encou
summary(fit3)
```

```
##
## Call:
## lm(formula = improveform ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + preform)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.7890 -1.6677  0.2768  1.6463  6.9293
##
## Coefficients: (2 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   2.46021    2.43719   1.009  0.31386
## sex           0.33124    0.35018   0.946  0.34523
## age           0.07161    0.04710   1.520  0.12987
## setting      -0.38683    0.40879  -0.946  0.34503
## viewenc       0.13689    0.41987   0.326  0.74471
## improveclasf  0.28536    0.04475   6.376 1.04e-09 ***
## improvebody   0.07785    0.03799   2.049  0.04164 *
## improverelat  0.09412    0.05828   1.615  0.10775
## peabody       0.02037    0.01533   1.329  0.18513
## agecat        0.20276    0.56125   0.361  0.71825
## encour             NA         NA      NA       NA
## regular       2.68778    0.62563   4.296 2.60e-05 ***
## s1           -0.18751    0.79234  -0.237  0.81314
## s2            0.39342    0.78953   0.498  0.61877
## s3           -1.21059    0.75950  -1.594  0.11238
## s4           -0.68070    0.80597  -0.845  0.39926
## vc1                NA         NA      NA       NA
## vc2          -1.53450    0.51243  -2.995  0.00306 **
## vc3          -0.93601    0.48560  -1.928  0.05519 .
## preform      -0.59619    0.06474  -9.210  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.638 on 222 degrees of freedom
## Multiple R-squared:  0.5395, Adjusted R-squared:  0.5043
## F-statistic:  15.3 on 17 and 222 DF,  p-value: < 2.2e-16
```

```
MSE3=(summary(fit3)$sigma)^2
step(fit3, scale=MSE3, direction="backward")
```

```
## Start:  AIC=18
## improveform ~ sex + age + +setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc1 + vc2 + vc3 + preform
##
##
## Step:  AIC=18
## improveform ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + encour +
##     regular + s1 + s2 + s3 + s4 + vc2 + vc3 + preform
##
##
## Step:  AIC=18
```

```
## improveform ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + regular +
##     s1 + s2 + s3 + s4 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - s1            1      0.39 1545.0  16.056
## - viewenc       1      0.74 1545.4  16.106
## - agecat        1      0.91 1545.6  16.131
## - s2            1      1.73 1546.4  16.248
## - s4            1      4.96 1549.6  16.713
## - sex           1      6.23 1550.9  16.895
## - setting       1      6.23 1550.9  16.895
## - peabody       1     12.29 1556.9  17.767
## <none>                      1544.7  18.000
## - age           1     16.08 1560.7  18.311
## - s3            1     17.68 1562.3  18.541
## - improverelat  1     18.15 1562.8  18.608
## - vc3           1     25.85 1570.5  19.715
## - improvebody   1     29.21 1573.9  20.198
## - vc2           1     62.39 1607.0  24.968
## - regular       1    128.42 1673.1  34.457
## - improveclasf  1    282.87 1827.5  56.655
## - preform       1    590.14 2134.8 100.816
##
## Step:  AIC=16.06
## improveform ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + agecat + regular +
##     s2 + s3 + s4 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - agecat        1      0.86 1545.9  14.180
## - viewenc       1      0.92 1546.0  14.188
## - setting       1      5.84 1550.9  14.896
## - sex           1      6.23 1551.3  14.951
## - s4            1      6.82 1551.9  15.037
## - s2            1      7.18 1552.2  15.088
## - peabody       1     13.64 1558.7  16.016
## <none>                      1545.0  16.056
## - age           1     16.87 1561.9  16.481
## - improverelat  1     17.88 1562.9  16.625
## - vc3           1     26.82 1571.9  17.911
## - improvebody   1     30.82 1575.9  18.485
## - s3            1     33.60 1578.7  18.886
## - vc2           1     62.46 1607.5  23.033
## - regular       1    128.59 1673.6  32.537
## - improveclasf  1    283.57 1828.6  54.812
## - preform       1    605.64 2150.7 101.099
##
## Step:  AIC=14.18
## improveform ~ sex + age + setting + viewenc + improveclasf +
##     improvebody + improverelat + peabody + regular + s2 + s3 +
##     s4 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS     Cp
```

```
## - viewenc       1      0.84 1546.7 12.301
## - sex           1      5.70 1551.6 12.999
## - setting       1      5.98 1551.9 13.039
## - s4            1      6.67 1552.6 13.139
## - s2            1      7.27 1553.2 13.225
## <none>                      1545.9 14.180
## - peabody       1     14.65 1560.5 14.285
## - improverelat  1     18.42 1564.3 14.827
## - vc3           1     26.90 1572.8 16.046
## - improvebody   1     31.34 1577.2 16.684
## - s3            1     33.02 1578.9 16.925
## - age           1     51.75 1597.7 19.618
## - vc2           1     62.39 1608.3 21.146
## - regular       1    129.69 1675.6 30.820
## - improveclasf  1    282.92 1828.8 52.842
## - preform       1    609.85 2155.8 99.829
##
## Step:  AIC=12.3
## improveform ~ sex + age + setting + improveclasf + improvebody +
##     improverelat + peabody + regular + s2 + s3 + s4 + vc2 + vc3 +
##     preform
##
##                Df Sum of Sq    RSS     Cp
## - setting       1      5.20 1551.9 11.048
## - sex           1      5.65 1552.4 11.113
## - s4            1      6.46 1553.2 11.229
## - s2            1      7.59 1554.3 11.391
## <none>                      1546.7 12.301
## - peabody       1     14.01 1560.8 12.314
## - improverelat  1     18.37 1565.1 12.940
## - vc3           1     26.79 1573.5 14.151
## - improvebody   1     31.20 1577.9 14.785
## - s3            1     32.19 1578.9 14.928
## - age           1     52.57 1599.3 17.856
## - vc2           1     61.66 1608.4 19.163
## - regular       1    144.03 1690.8 31.002
## - improveclasf  1    288.30 1835.0 51.735
## - preform       1    611.65 2158.4 98.208
##
## Step:  AIC=11.05
## improveform ~ sex + age + improveclasf + improvebody + improverelat +
##     peabody + regular + s2 + s3 + s4 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - sex           1      5.07 1557.0  9.7759
## - s4            1      5.76 1557.7  9.8751
## - s2            1      8.62 1560.6 10.2866
## - peabody       1     11.44 1563.4 10.6916
## <none>                      1551.9 11.0477
## - improverelat  1     17.99 1569.9 11.6328
## - vc3           1     26.83 1578.8 12.9043
## - improvebody   1     29.35 1581.3 13.2655
## - s3            1     35.25 1587.2 14.1142
## - vc2           1     60.84 1612.8 17.7913
```

```
## - age           1     64.97 1616.9 18.3859
## - regular       1    139.55 1691.5 29.1037
## - improveclasf  1    293.06 1845.0 51.1670
## - preform       1    611.05 2163.0 96.8686
##
## Step:  AIC=9.78
## improveform ~ age + improveclasf + improvebody + improverelat +
##     peabody + regular + s2 + s3 + s4 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - s4            1      6.44 1563.5  8.7015
## - s2            1      7.75 1564.8  8.8895
## - peabody       1     11.96 1569.0  9.4942
## <none>                      1557.0  9.7759
## - improverelat  1     18.61 1575.6 10.4503
## - vc3           1     25.88 1582.9 11.4959
## - improvebody   1     30.93 1587.9 12.2218
## - s3            1     36.13 1593.1 12.9683
## - vc2           1     59.78 1616.8 16.3682
## - age           1     68.35 1625.4 17.5991
## - regular       1    139.92 1696.9 27.8853
## - improveclasf  1    288.77 1845.8 49.2777
## - preform       1    608.34 2165.3 95.2069
##
## Step:  AIC=8.7
## improveform ~ age + improveclasf + improvebody + improverelat +
##     peabody + regular + s2 + s3 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - peabody       1     11.84 1575.3  8.4031
## - s2            1     12.93 1576.4  8.5601
## <none>                      1563.5  8.7015
## - improverelat  1     14.95 1578.4  8.8497
## - vc3           1     27.31 1590.8 10.6272
## - improvebody   1     28.31 1591.8 10.7707
## - s3            1     29.73 1593.2 10.9746
## - vc2           1     63.98 1627.4 15.8963
## - age           1     64.59 1628.0 15.9838
## - regular       1    169.13 1732.6 31.0085
## - improveclasf  1    305.38 1868.8 50.5912
## - preform       1    609.27 2172.7 94.2670
##
## Step:  AIC=8.4
## improveform ~ age + improveclasf + improvebody + improverelat +
##     regular + s2 + s3 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## - improverelat  1     12.48 1587.8  8.1963
## <none>                      1575.3  8.4031
## - improvebody   1     24.47 1599.8  9.9193
## - s2            1     29.40 1604.7 10.6283
## - vc3           1     29.82 1605.1 10.6887
## - s3            1     33.41 1608.7 11.2043
## - vc2           1     63.21 1638.5 15.4877
```

```
## - age           1     78.08 1653.4 17.6245
## - regular       1    173.05 1748.3 31.2744
## - improveclasf  1    327.94 1903.2 53.5348
## - preform       1    619.30 2194.6 95.4094
##
## Step:  AIC=8.2
## improveform ~ age + improveclasf + improvebody + regular + s2 +
##     s3 + vc2 + vc3 + preform
##
##                Df Sum of Sq    RSS      Cp
## <none>                      1587.8  8.1963
## - s2            1     27.09 1614.8 10.0894
## - s3            1     30.09 1617.8 10.5208
## - improvebody   1     30.30 1618.1 10.5511
## - vc3           1     34.56 1622.3 11.1640
## - age           1     70.17 1657.9 16.2809
## - vc2           1     70.55 1658.3 16.3356
## - regular       1    184.32 1772.1 32.6866
## - improveclasf  1    422.97 2010.7 66.9860
## - preform       1    628.83 2216.6 96.5724
```

```
##
## Call:
## lm(formula = improveform ~ age + improveclasf + improvebody +
##     regular + s2 + s3 + vc2 + vc3 + preform)
##
## Coefficients:
##  (Intercept)           age  improveclasf   improvebody       regular
##      1.69450       0.09217       0.31890       0.07620       2.93696
##           s2            s3           vc2           vc3       preform
##      0.90603      -0.91110      -1.60872      -1.06510      -0.56394
```

```
none=lm(improveform~1)
step(none, scope=list(upper=fit3), scale=MSE3)
```

```
## Start:  AIC=244.12
## improveform ~ 1
##
##                Df Sum of Sq    RSS     Cp
## + improveclasf  1    962.15 2392.4 107.84
## + preform       1    613.92 2740.6 157.89
## + improverelat  1    361.93 2992.6 194.11
## + improvebody   1    358.44 2996.1 194.61
## + regular       1     74.60 3280.0 235.40
## + vc1           1     74.60 3280.0 235.40
## + s4            1     36.59 3318.0 240.86
## + viewenc       1     27.99 3326.6 242.10
## + encour        1     27.99 3326.6 242.10
## + setting       1     27.42 3327.1 242.18
## + s1            1     23.83 3330.7 242.70
## + s2            1     17.60 3337.0 243.59
## + peabody       1     16.49 3338.1 243.75
## <none>                      3354.6 244.12
## + s3            1     10.31 3344.2 244.64
## + age           1      4.34 3350.2 245.50
```

```
## + vc2           1      2.57 3352.0 245.75
## + vc3           1      0.53 3354.0 246.05
## + agecat        1      0.33 3354.2 246.08
## + sex           1      0.00 3354.6 246.12
##
## Step:  AIC=107.84
## improveform ~ improveclasf
##
##                Df Sum of Sq    RSS      Cp
## + preform       1    444.56 1947.8  45.948
## + improvebody   1    142.06 2250.4  89.424
## + improverelat  1     53.44 2339.0 102.161
## + peabody       1     34.89 2357.5 104.827
## + s1            1     13.93 2378.5 107.839
## <none>                      2392.4 107.841
## + setting       1     13.80 2378.6 107.858
## + s3            1     13.59 2378.8 107.888
## + regular       1     11.62 2380.8 108.172
## + vc1           1     11.62 2380.8 108.172
## + s4            1      6.87 2385.5 108.854
## + sex           1      4.36 2388.0 109.214
## + viewenc       1      1.74 2390.7 109.591
## + encour        1      1.74 2390.7 109.591
## + agecat        1      1.61 2390.8 109.610
## + vc2           1      0.72 2391.7 109.737
## + vc3           1      0.57 2391.8 109.759
## + age           1      0.12 2392.3 109.824
## + s2            1      0.11 2392.3 109.826
## - improveclasf  1    962.15 3354.6 244.124
##
## Step:  AIC=45.95
## improveform ~ improveclasf + preform
##
##                Df Sum of Sq    RSS      Cp
## + regular       1    117.99 1829.9  30.990
## + vc1           1    117.99 1829.9  30.990
## + s2            1     57.29 1890.5  39.714
## + improvebody   1     47.88 1900.0  41.066
## + peabody       1     42.75 1905.1  41.803
## + age           1     32.39 1915.5  43.292
## + agecat        1     32.22 1915.6  43.318
## + s4            1     18.92 1928.9  45.228
## + improverelat  1     17.62 1930.2  45.416
## <none>                      1947.8  45.948
## + sex           1     11.37 1936.5  46.313
## + s3            1     10.98 1936.9  46.370
## + viewenc       1      8.31 1939.5  46.754
## + encour        1      8.31 1939.5  46.754
## + vc2           1      6.75 1941.1  46.978
## + vc3           1      1.69 1946.2  47.705
## + s1            1      0.81 1947.0  47.831
## + setting       1      0.15 1947.7  47.926
## - preform       1    444.56 2392.4 107.841
## - improveclasf  1    792.80 2740.6 157.890
```

```
##
## Step:  AIC=30.99
## improveform ~ improveclasf + preform + regular
##
##                Df Sum of Sq    RSS      Cp
## + vc2           1     50.32 1779.5  25.758
## + s2            1     44.47 1785.4  26.598
## + age           1     44.44 1785.4  26.603
## + peabody       1     40.83 1789.0  27.122
## + agecat        1     37.76 1792.1  27.563
## + improvebody   1     31.33 1798.5  28.487
## + s3            1     28.96 1800.9  28.829
## <none>                      1829.9  30.990
## + improverelat  1     11.30 1818.6  31.367
## + setting       1      8.06 1821.8  31.831
## + sex           1      7.80 1822.0  31.869
## + vc3           1      4.63 1825.2  32.324
## + s1            1      2.87 1827.0  32.578
## + viewenc       1      2.74 1827.1  32.596
## + encour        1      2.74 1827.1  32.596
## + s4            1      0.71 1829.1  32.888
## - regular       1    117.99 1947.8  45.948
## - preform       1    550.94 2380.8 108.172
## - improveclasf  1    630.07 2459.9 119.545
##
## Step:  AIC=25.76
## improveform ~ improveclasf + preform + regular + vc2
##
##                Df Sum of Sq    RSS      Cp
## + vc3           1     45.92 1733.6  21.159
## + peabody       1     43.45 1736.1  21.512
## + age           1     42.90 1736.6  21.592
## + agecat        1     36.64 1742.9  22.492
## + s2            1     35.97 1743.6  22.589
## + s3            1     35.56 1744.0  22.647
## + improvebody   1     25.71 1753.8  24.062
## <none>                      1779.5  25.758
## + setting       1      9.48 1770.0  26.395
## + sex           1      8.14 1771.4  26.587
## + improverelat  1      8.07 1771.5  26.598
## + s1            1      2.17 1777.4  27.446
## + viewenc       1      1.69 1777.8  27.515
## + encour        1      1.69 1777.8  27.515
## + s4            1      0.01 1779.5  27.756
## - vc2           1     50.32 1829.9  30.990
## - regular       1    161.56 1941.1  46.978
## - improveclasf  1    578.46 2358.0 106.895
## - preform       1    597.06 2376.6 109.568
##
## Step:  AIC=21.16
## improveform ~ improveclasf + preform + regular + vc2 + vc3
##
##                Df Sum of Sq    RSS      Cp
## + age           1     42.62 1691.0  17.033
```

```
## + peabody       1     37.65 1696.0  17.748
## + s3            1     34.93 1698.7  18.138
## + agecat        1     34.78 1698.8  18.160
## + s2            1     30.50 1703.1  18.776
## + improvebody   1     21.19 1712.4  20.113
## <none>                      1733.6  21.159
## + setting       1     10.02 1723.6  21.718
## + sex           1      9.62 1724.0  21.776
## + improverelat  1      4.45 1729.2  22.519
## + viewenc       1      1.40 1732.2  22.957
## + encour        1      1.40 1732.2  22.957
## + s1            1      0.80 1732.8  23.043
## + s4            1      0.02 1733.6  23.156
## - vc3           1     45.92 1779.5  25.758
## - vc2           1     91.60 1825.2  32.324
## - regular       1    207.29 1940.9  48.950
## - improveclasf  1    547.56 2281.2  97.855
## - preform       1    631.04 2364.7 109.852
##
## Step:  AIC=17.03
## improveform ~ improveclasf + preform + regular + vc2 + vc3 +
##     age
##
##                Df Sum of Sq    RSS      Cp
## + s3            1     51.65 1639.3  11.610
## + s2            1     40.50 1650.5  13.213
## + peabody       1     28.53 1662.5  14.932
## + improvebody   1     25.02 1666.0  15.437
## <none>                      1691.0  17.033
## + improverelat  1      9.57 1681.4  17.658
## + sex           1      6.62 1684.4  18.082
## + setting       1      3.47 1687.5  18.535
## + agecat        1      1.84 1689.2  18.769
## + viewenc       1      1.37 1689.6  18.836
## + encour        1      1.37 1689.6  18.836
## + s1            1      0.01 1691.0  19.032
## + s4            1      0.01 1691.0  19.032
## - age           1     42.62 1733.6  21.159
## - vc3           1     45.63 1736.6  21.592
## - vc2           1     89.61 1780.6  27.912
## - regular       1    218.59 1909.6  46.449
## - improveclasf  1    549.07 2240.1  93.947
## - preform       1    673.20 2364.2 111.787
##
## Step:  AIC=11.61
## improveform ~ improveclasf + preform + regular + vc2 + vc3 +
##     age + s3
##
##                Df Sum of Sq    RSS      Cp
## + improvebody   1     24.50 1614.8  10.089
## + s2            1     21.29 1618.1  10.551
## + peabody       1     16.00 1623.3  11.311
## + improverelat  1     15.17 1624.2  11.431
## <none>                      1639.3  11.610
```

```
## + s1            1      6.97 1632.4  12.608
## + sex           1      6.72 1632.6  12.645
## + s4            1      5.40 1634.0  12.834
## + agecat        1      2.46 1636.9  13.257
## + setting       1      1.03 1638.3  13.462
## + viewenc       1      0.01 1639.3  13.609
## + encour        1      0.01 1639.3  13.609
## - vc3           1     44.81 1684.2  16.050
## - s3            1     51.65 1691.0  17.033
## - age           1     59.34 1698.7  18.138
## - vc2           1     97.92 1737.3  23.684
## - regular       1    251.13 1890.5  45.703
## - improveclasf  1    507.52 2146.9  82.552
## - preform       1    710.79 2350.1 111.766
##
## Step:  AIC=10.09
## improveform ~ improveclasf + preform + regular + vc2 + vc3 +
##     age + s3 + improvebody
##
##                Df Sum of Sq    RSS      Cp
## + s2            1     27.09 1587.8  8.1963
## + peabody       1     24.02 1590.8  8.6375
## <none>                      1614.8 10.0894
## + improverelat  1     10.17 1604.7 10.6283
## + s4            1     10.05 1604.8 10.6448
## + sex           1      5.31 1609.5 11.3259
## + s1            1      4.88 1610.0 11.3876
## - improvebody   1     24.50 1639.3 11.6103
## + agecat        1      2.09 1612.8 11.7886
## + setting       1      1.65 1613.2 11.8530
## + viewenc       1      0.00 1614.8 12.0894
## + encour        1      0.00 1614.8 12.0894
## - vc3           1     40.02 1654.9 13.8408
## - s3            1     51.12 1666.0 15.4368
## - age           1     63.59 1678.5 17.2292
## - vc2           1     87.10 1702.0 20.6072
## - regular       1    221.55 1836.4 39.9312
## - improveclasf  1    457.52 2072.4 73.8451
## - preform       1    605.73 2220.6 95.1454
##
## Step:  AIC=8.2
## improveform ~ improveclasf + preform + regular + vc2 + vc3 +
##     age + s3 + improvebody + s2
##
##                Df Sum of Sq    RSS      Cp
## <none>                      1587.8  8.1963
## + improverelat  1     12.48 1575.3  8.4031
## + peabody       1      9.37 1578.4  8.8497
## + sex           1      6.57 1581.2  9.2514
## + s4            1      2.93 1584.8  9.7745
## + setting       1      1.81 1586.0  9.9364
## + agecat        1      1.22 1586.5 10.0205
## - s2            1     27.09 1614.8 10.0894
## + s1            1      0.71 1587.0 10.0941
```

```
## + viewenc       1      0.00 1587.8 10.1962
## + encour        1      0.00 1587.8 10.1962
## - s3            1     30.09 1617.8 10.5208
## - improvebody   1     30.30 1618.1 10.5511
## - vc3           1     34.56 1622.3 11.1640
## - age           1     70.17 1657.9 16.2809
## - vc2           1     70.55 1658.3 16.3356
## - regular       1    184.32 1772.1 32.6866
## - improveclasf  1    422.97 2010.7 66.9860
## - preform       1    628.83 2216.6 96.5724
```

```
##
## Call:
## lm(formula = improveform ~ improveclasf + preform + regular +
##     vc2 + vc3 + age + s3 + improvebody + s2)
##
## Coefficients:
##  (Intercept)  improveclasf       preform       regular           vc2
##      1.69450       0.31890      -0.56394       2.93696      -1.60872
##          vc3           age            s3   improvebody            s2
##     -1.06510       0.09217      -0.91110       0.07620       0.90603
```

```
fitnumb=lm(improvenumb ~ age + setting + improveclasf + improvebody +
    improverelat + regular + s1 + s3 + s4 + vc2 + prenumb)
```

```
fitlet=lm(improvelet ~ age + improveclasf + improvebody +
    peabody + regular + s2 + s3 + vc2 + prelet)
```

```
fitform=lm(improveform ~ age + improveclasf + improvebody +
    regular + s2 + s3 + vc2 + vc3 + preform)
```

```
library(car)
vif(fitnumb)
```

```
##          age      setting improveclasf  improvebody improverelat
##     1.416666     1.188046     1.307876     1.239401     1.373446
##      regular           s1           s3           s4          vc2
##     1.458296     1.450593     1.643332     1.654628     1.183147
##      prenumb
##     1.686522
```

```
vif(fitlet)
```

```
##          age improveclasf  improvebody      peabody      regular
##     1.213414     1.117841     1.166377     1.750337     1.281832
##           s2           s3          vc2       prelet
##     1.540665     1.227579     1.165028     1.308130
```

```
vif(fitform)
```

```
##          age improveclasf  improvebody      regular           s2
##     1.141672     1.152656     1.178393     1.958513     1.284762
##           s3          vc2          vc3      preform
##     1.294780     1.650758     1.540375     1.685507
```

```
summary(fitnumb)
```

```
##
```

```
## Call:
## lm(formula = improvenumb ~ age + setting + improveclasf + improvebody +
##     improverelat + regular + s1 + s3 + s4 + vc2 + prenumb)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -29.6134  -5.2796   0.4747   5.1154  19.6492
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.10084    4.74760   0.021 0.983073
## age           0.22069    0.09215   2.395 0.017434 *
## setting      -2.18031    1.07794  -2.023 0.044275 *
## improveclasf  0.69644    0.12418   5.608 5.89e-08 ***
## improvebody   0.15334    0.10674   1.437 0.152215
## improverelat  0.52718    0.16396   3.215 0.001492 **
## regular       5.82453    1.40346   4.150 4.69e-05 ***
## s1           -3.81957    1.34987  -2.830 0.005077 **
## s3           -4.98011    1.40685  -3.540 0.000485 ***
## s4           -4.63062    1.62785  -2.845 0.004851 **
## vc2          -2.44077    1.21910  -2.002 0.046457 *
## prenumb      -0.27622    0.05911  -4.673 5.07e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.518 on 228 degrees of freedom
## Multiple R-squared:  0.4263, Adjusted R-squared:  0.3986
## F-statistic:  15.4 on 11 and 228 DF,  p-value: < 2.2e-16
```

```
summary(fitlet)
```

```
##
## Call:
## lm(formula = improvelet ~ age + improveclasf + improvebody +
##     peabody + regular + s2 + s3 + vc2 + prelet)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -26.1732  -4.9991  -0.4583   4.6262  20.8643
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -9.75733    4.64297  -2.102 0.036683 *
## age           0.25973    0.09226   2.815 0.005298 **
## improveclasf  0.54348    0.12420   4.376 1.83e-05 ***
## improvebody   0.22414    0.11202   2.001 0.046567 *
## peabody       0.06387    0.04340   1.472 0.142471
## regular      10.63175    1.42342   7.469 1.67e-12 ***
## s2            6.38403    1.55046   4.118 5.34e-05 ***
## s3           -4.87814    1.31538  -3.709 0.000261 ***
## vc2          -5.84246    1.30867  -4.464 1.26e-05 ***
## prelet       -0.34504    0.07049  -4.895 1.85e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 8.133 on 230 degrees of freedom
## Multiple R-squared:  0.4896, Adjusted R-squared:  0.4696
## F-statistic: 24.52 on 9 and 230 DF,  p-value: < 2.2e-16
```

```
summary(fitform)
```

```
##
## Call:
## lm(formula = improveform ~ age + improveclasf + improvebody +
##     regular + s2 + s3 + vc2 + vc3 + preform)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.4959 -1.4593  0.4011  1.7237  7.3122
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   1.69450    1.48989   1.137  0.25658
## age           0.09217    0.02891   3.188  0.00163 **
## improveclasf  0.31890    0.04074   7.828 1.81e-13 ***
## improvebody   0.07620    0.03637   2.095  0.03726 *
## regular       2.93696    0.56839   5.167 5.15e-07 ***
## s2            0.90603    0.45738   1.981  0.04879 *
## s3           -0.91110    0.43640  -2.088  0.03792 *
## vc2          -1.60872    0.50323  -3.197  0.00158 **
## vc3          -1.06510    0.47599  -2.238  0.02620 *
## preform      -0.56394    0.05909  -9.544  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.627 on 230 degrees of freedom
## Multiple R-squared:  0.5267, Adjusted R-squared:  0.5082
## F-statistic: 28.44 on 9 and 230 DF,  p-value: < 2.2e-16
```

```
mean(improvenumb)
```

```
## [1] 9.154167
```

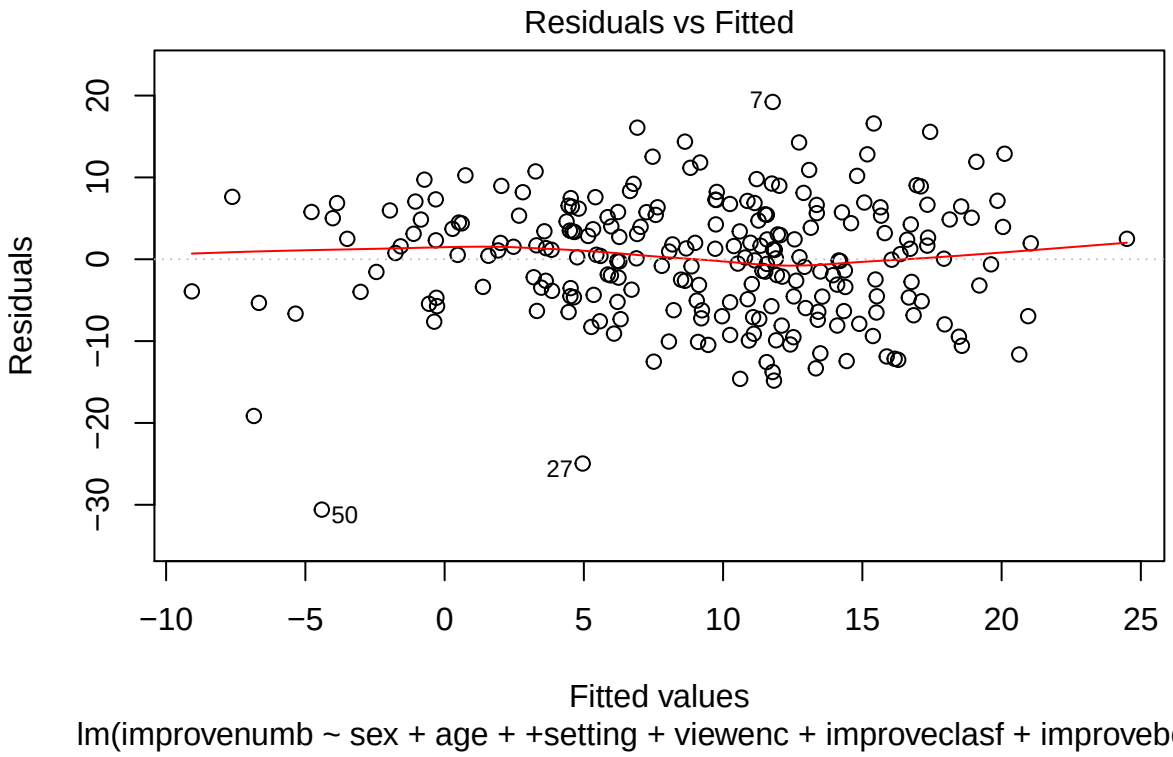
```
mean(improvelet)
```

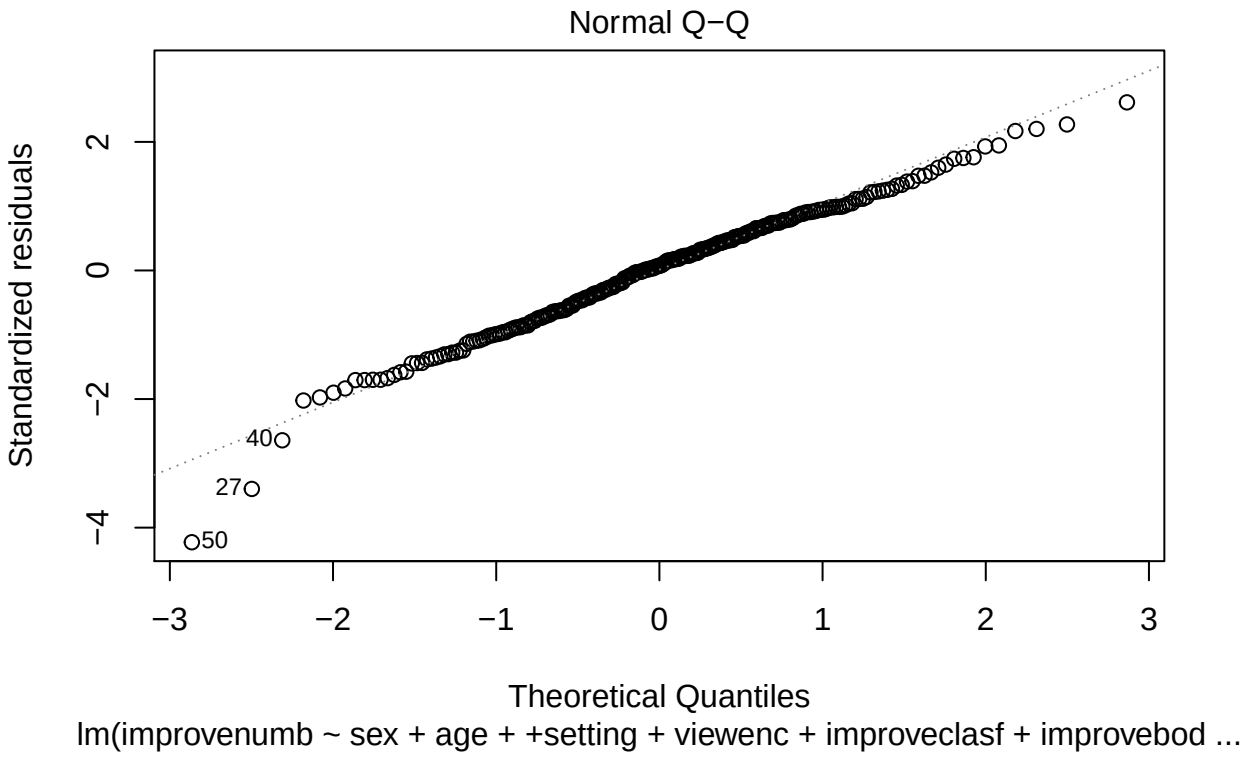
```
## [1] 10.80417
```

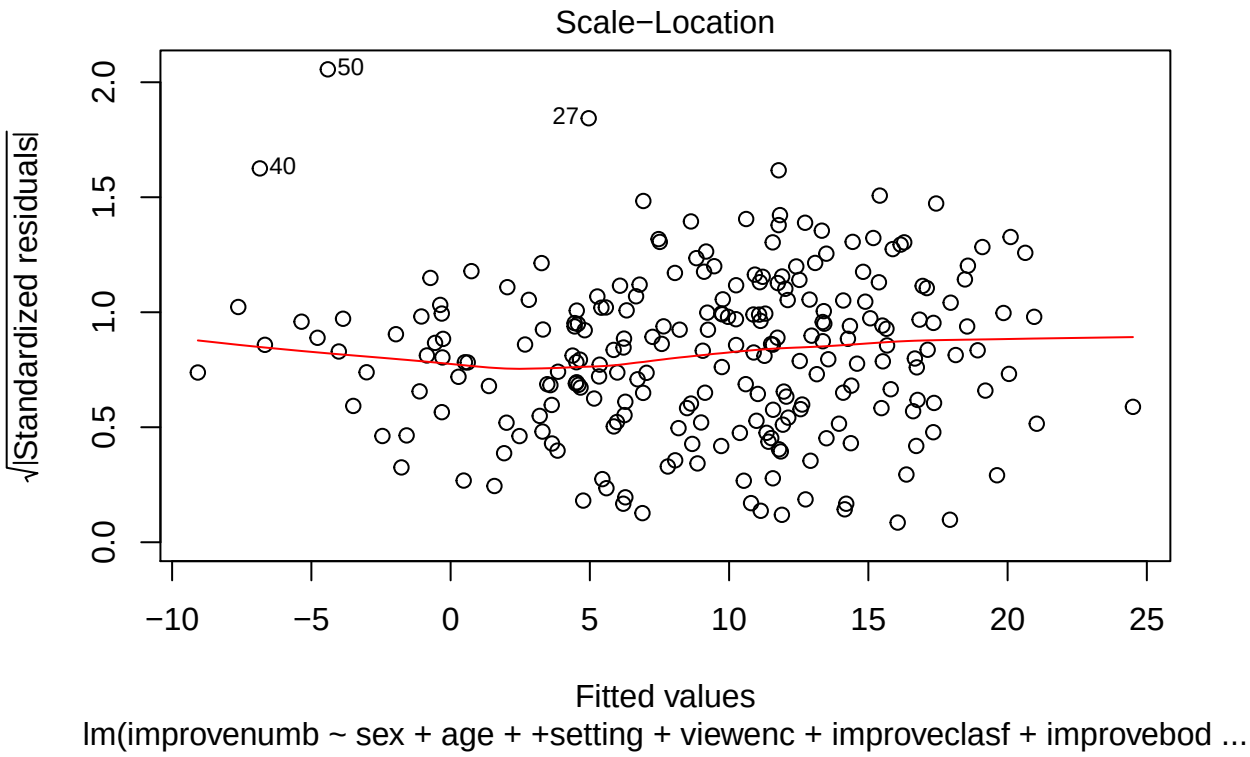
```
mean(improveform)
```

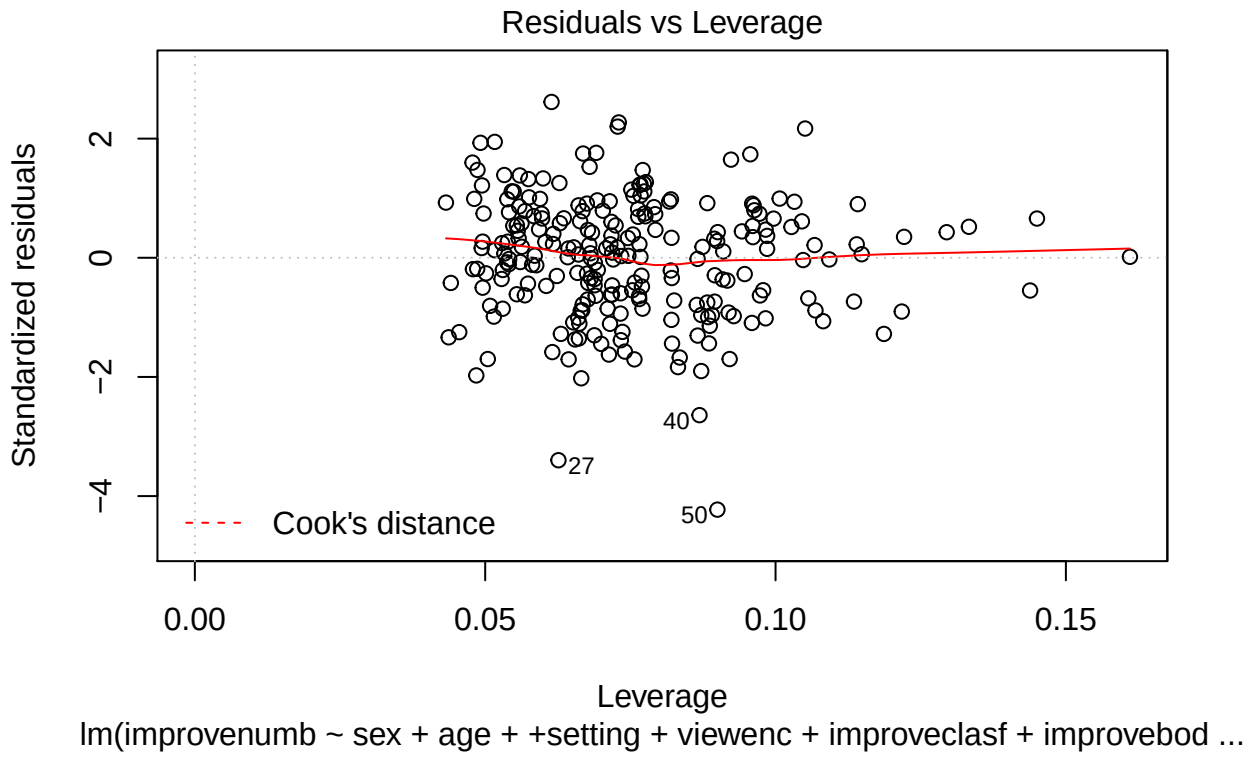
```
## [1] 3.8125
```

```
plot(fit1)
```

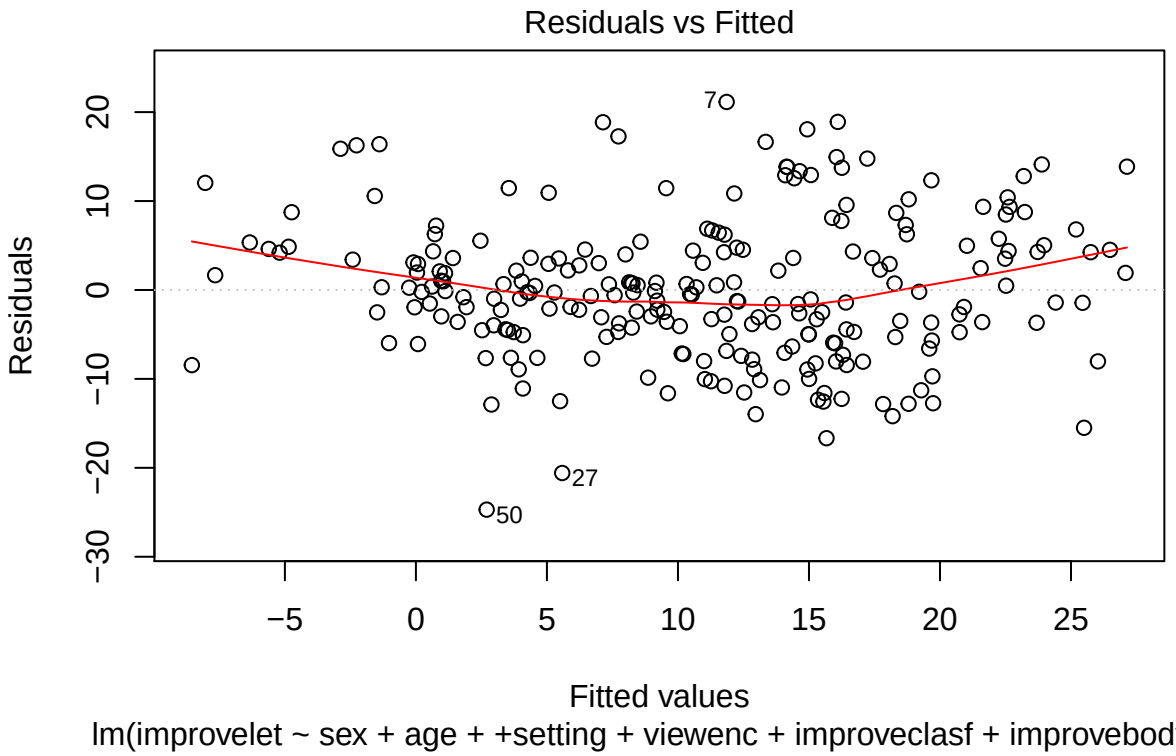

Residuals vs Fitted
Residuals
Fitted values
lm(improvenumb ~ sex + age + +setting + viewenc + improveclasf + improvebod ...
7
27
50
20
10
0
−10
−20
−30
−10
−5
0
5
10
15
20
25

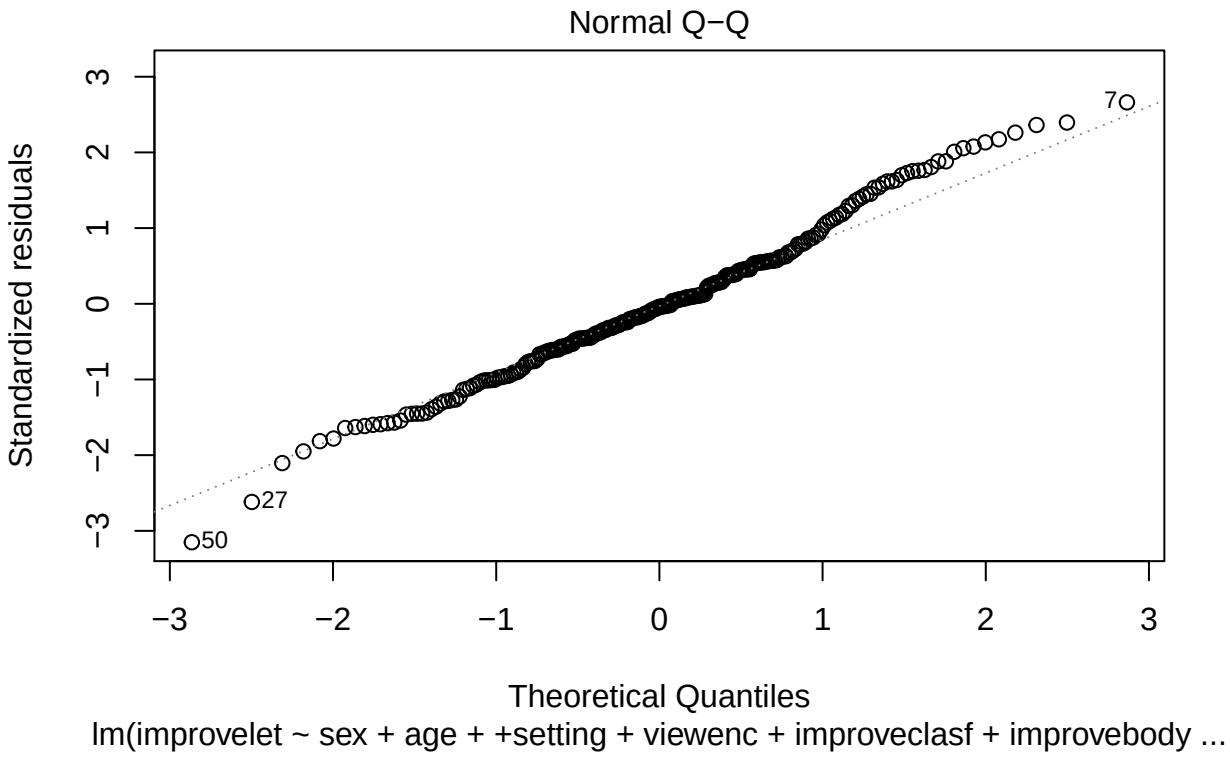

Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(improvenumb ~ sex + age + +setting + viewenc + improveclasf + improvebod ...
40
27
50
−4
−2
0
2
−3
−2
−1
0
1
2
3

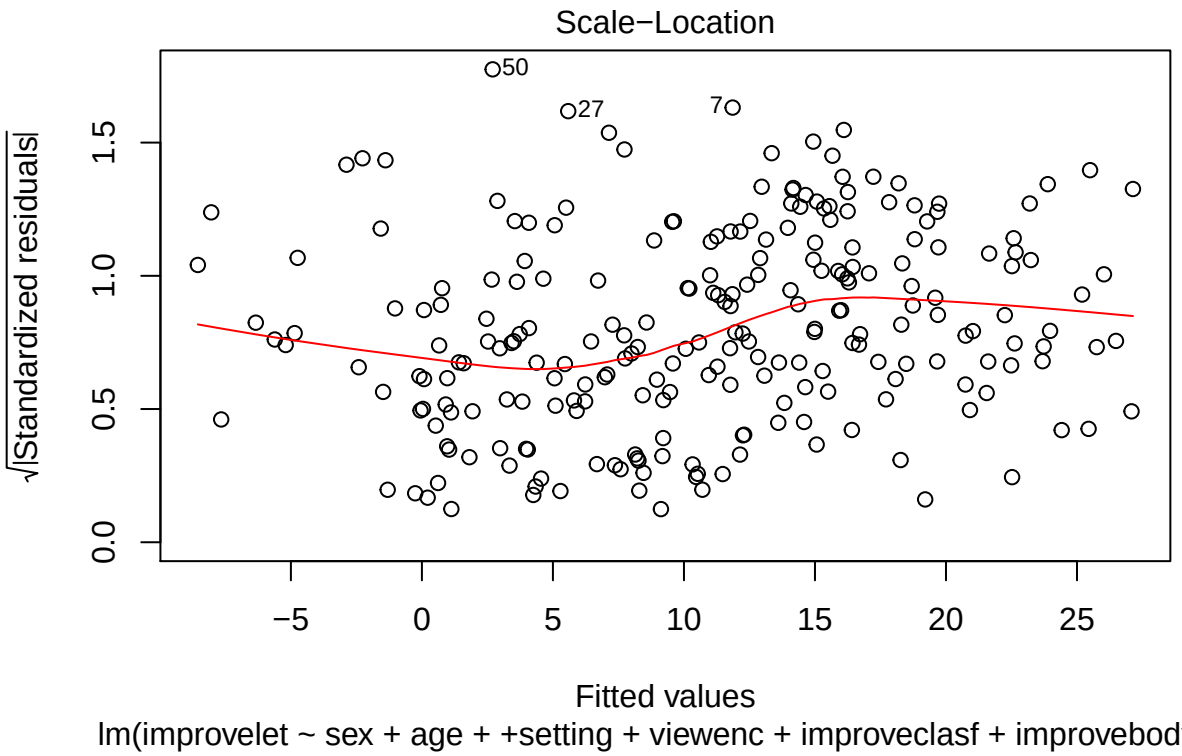

Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
50
27
40
−10
−5
0
5
10
15
20
25
Fitted values
lm(improvenumb ~ sex + age + +setting + viewenc + improveclasf + improvebod ...

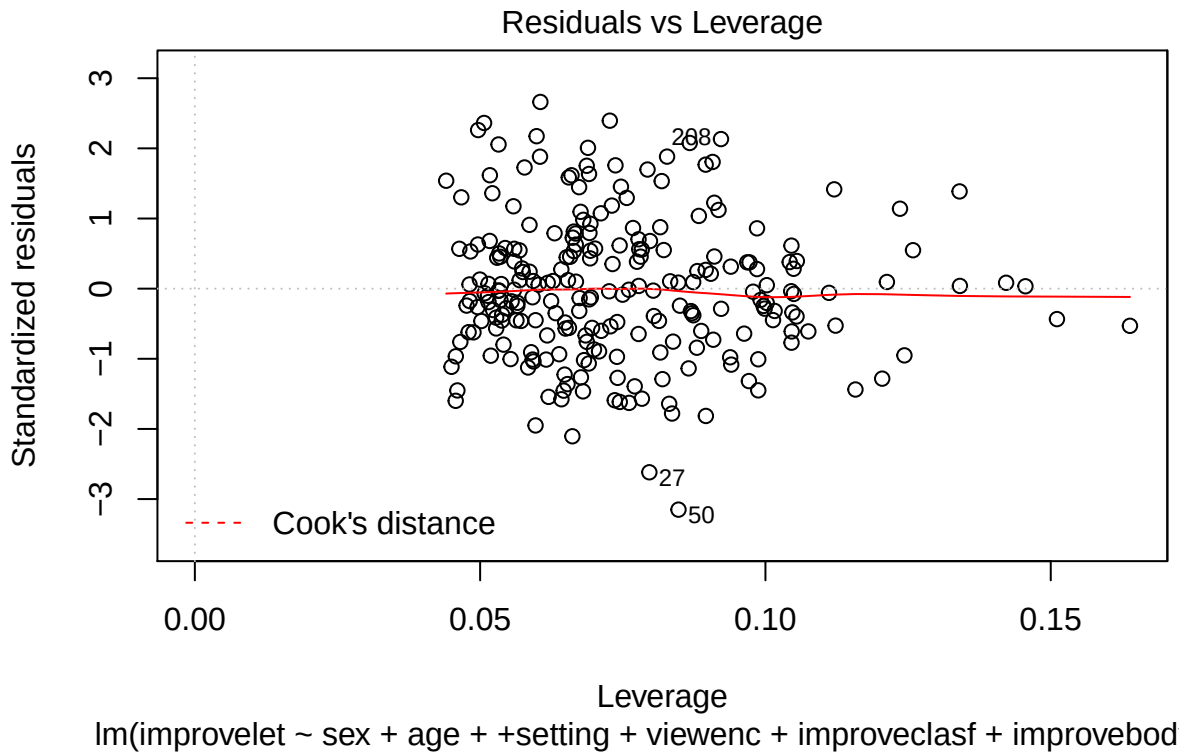

Residuals vs Leverage
Standardized residuals
2
0
−2
−4
40
27
50
Cook's distance
0.00
0.05
0.10
0.15
Leverage
lm(improvenumb ~ sex + age + +setting + viewenc + improveclasf + improvebod ...

```
plot(fit2)
```

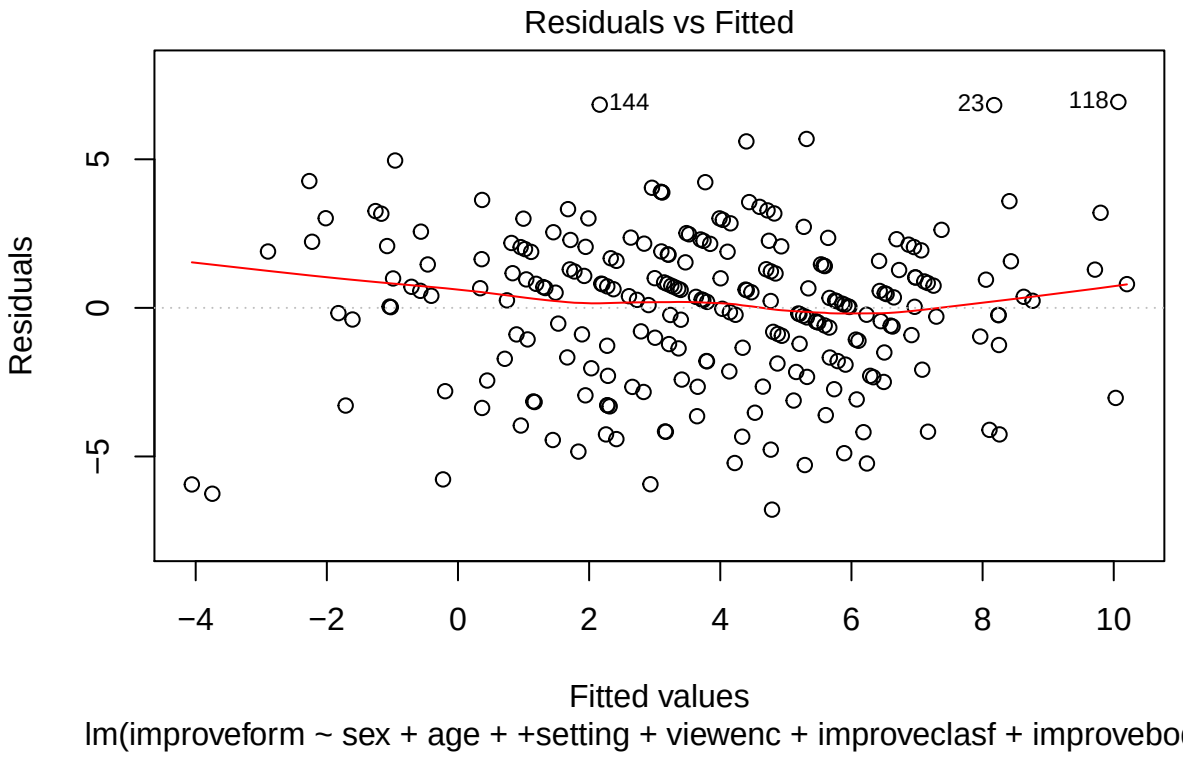

Residuals vs Fitted
Residuals
Fitted values
lm(improvelet ~ sex + age + +setting + viewenc + improveclasf + improvebody ...
7
27
50
20
10
0
−10
−20
−30
−5
0
5
10
15
20
25

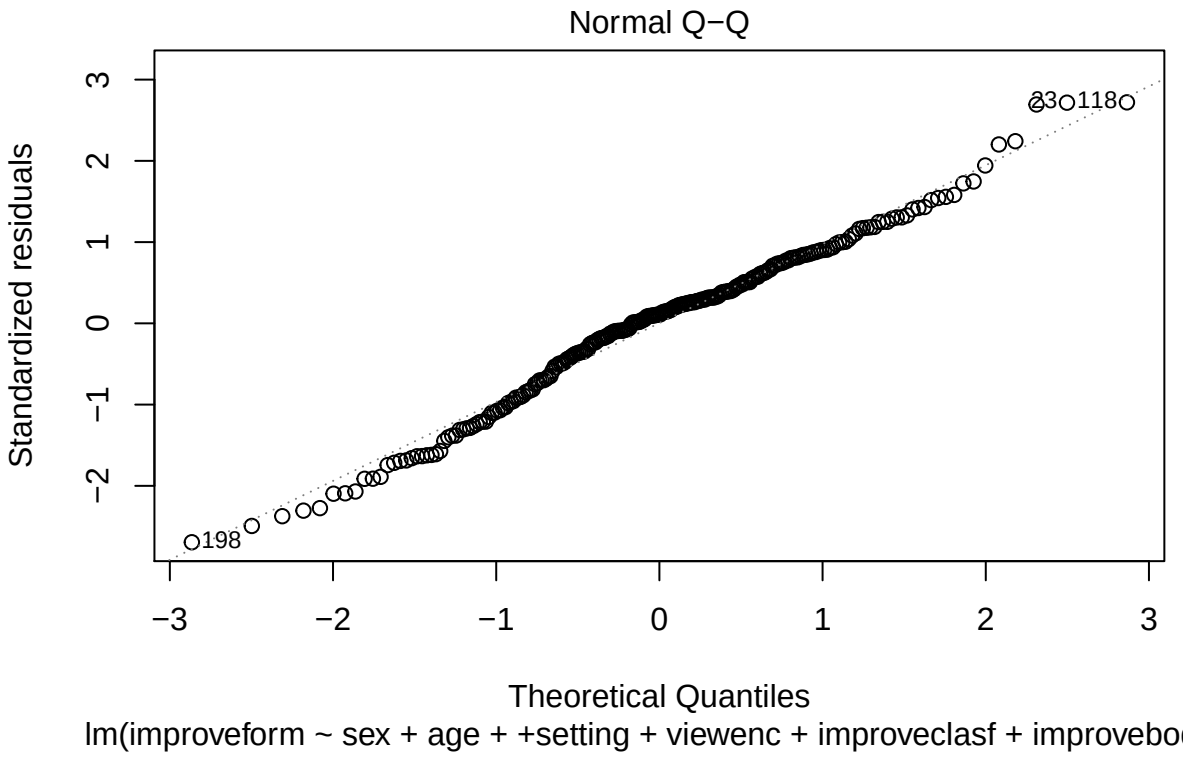

Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(improvelet ~ sex + age + +setting + viewenc + improveclasf + improvebody ...
7
27
50
−3
−2
−1
0
1
2
3

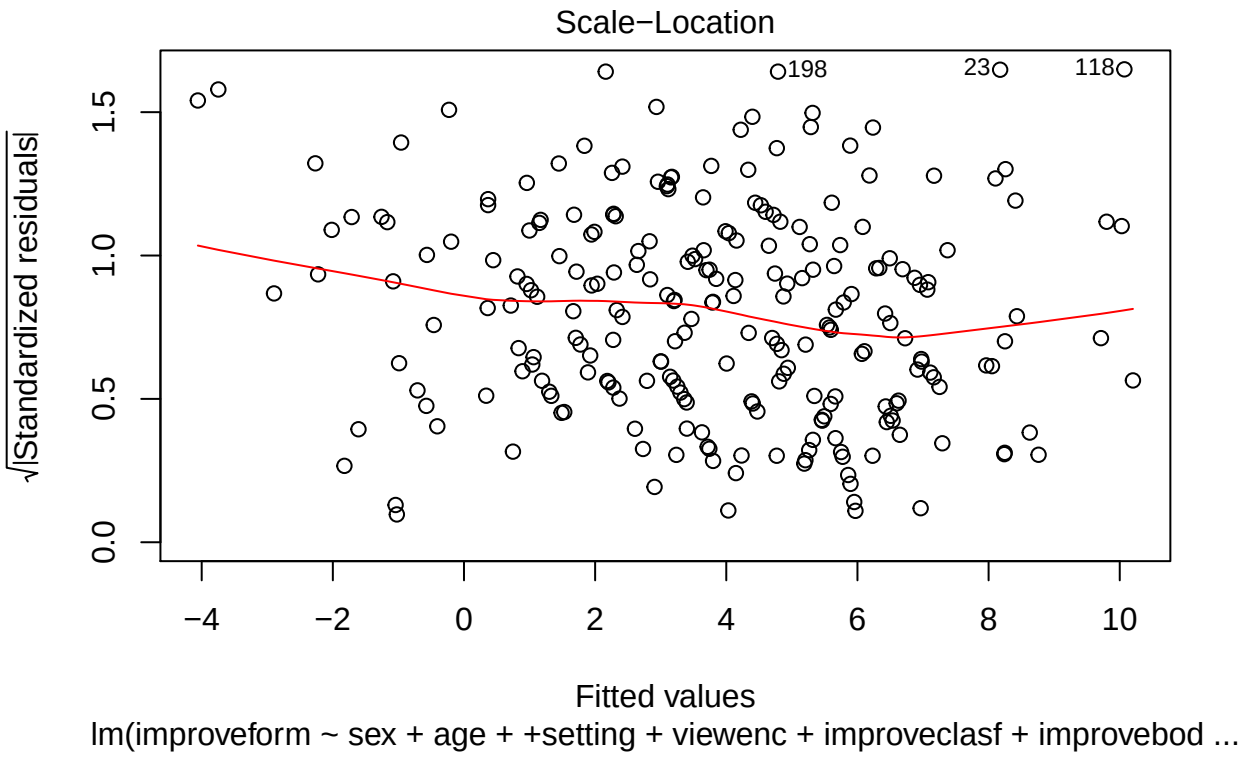

Scale−Location
50
27
7
√|Standardized residuals|
0.0
0.5
1.0
1.5
−5
0
5
10
15
20
25
Fitted values
lm(improvelet ~ sex + age + +setting + viewenc + improveclasf + improvebody ...

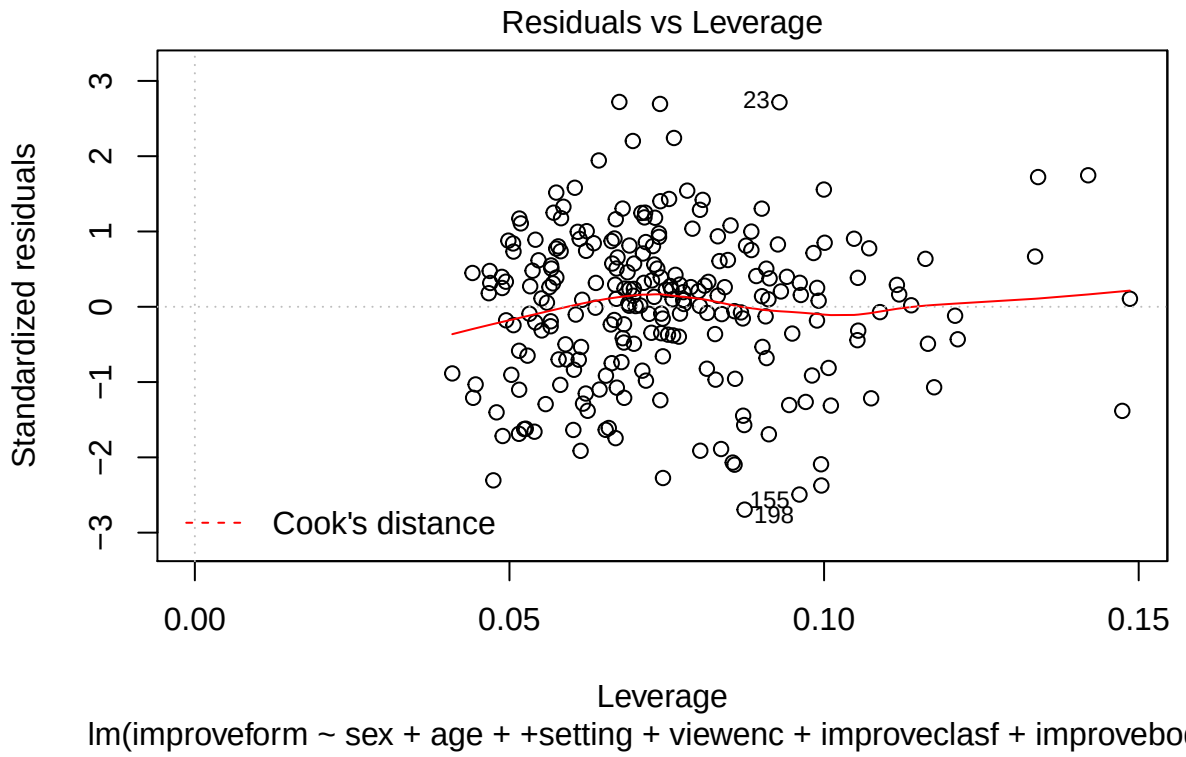

Residuals vs Leverage
Standardized residuals
3
2
1
0
−1
−2
−3
208
27
50
Cook's distance
0.00
0.05
0.10
0.15
Leverage
lm(improvelet ~ sex + age + +setting + viewenc + improveclasf + improvebody ...

```
plot(fit3)
```

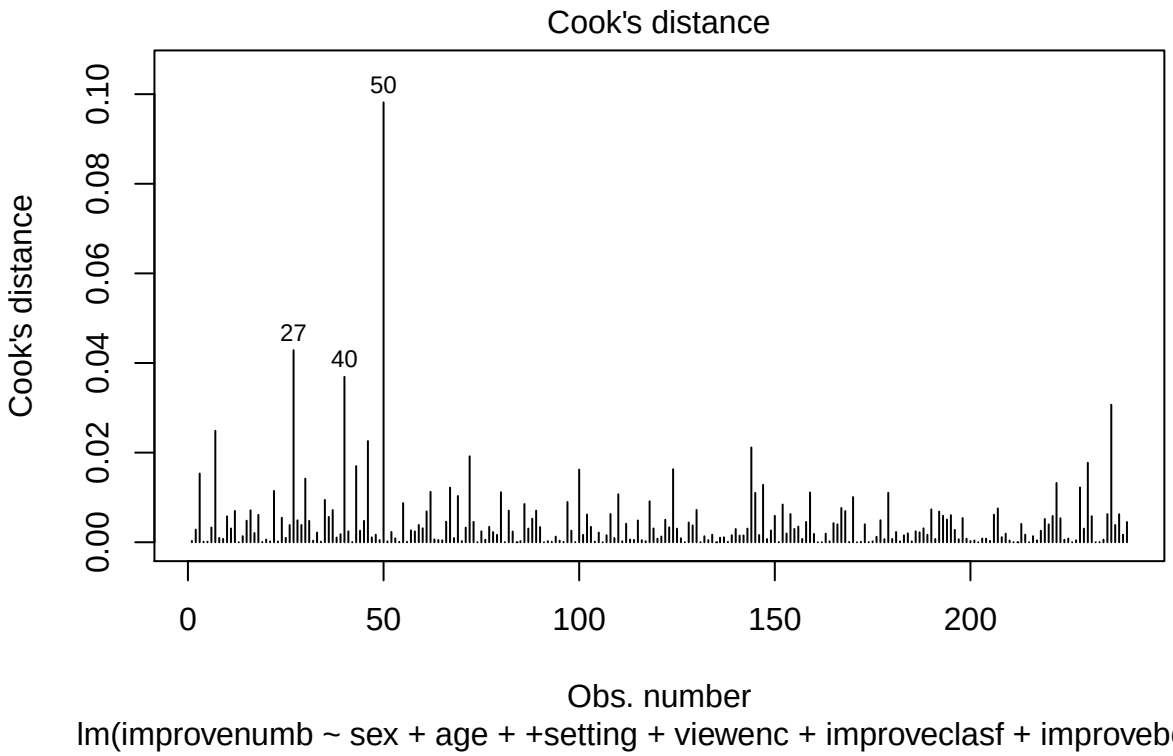

Residuals vs Fitted
144
23
118
Residuals
5
0
−5
−4
−2
0
2
4
6
8
10
Fitted values
lm(improveform ~ sex + age + +setting + viewenc + improveclasf + improvebod ...


Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(improveform ~ sex + age + +setting + viewenc + improveclasf + improvebod ...
198
23
118
−3
−2
−1
0
1
2
3

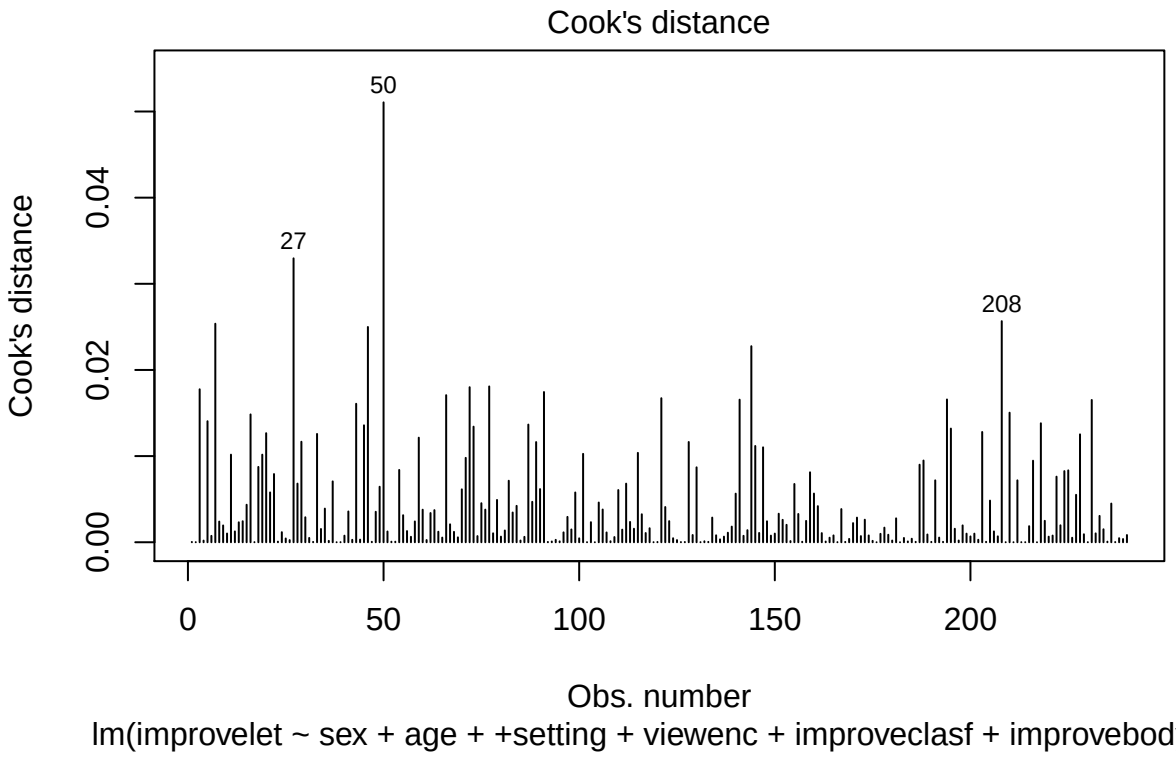

Scale−Location
198
23
118
√|Standardized residuals|
0.0
0.5
1.0
1.5
−4
−2
0
2
4
6
8
10
Fitted values
lm(improveform ~ sex + age + +setting + viewenc + improveclasf + improvebod ...



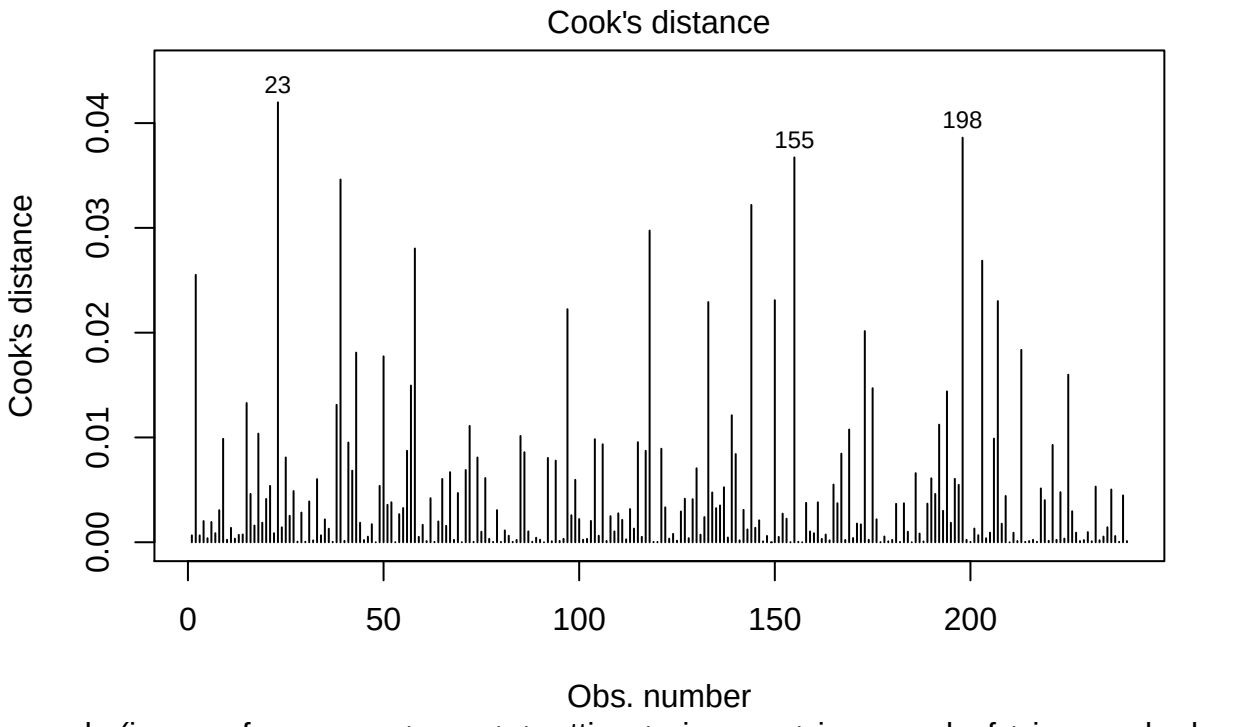

```
plot(fit1,which=4)
```




```
plot(fit2,which=4)
```




```
plot(fit3,which=4)
```


Cook's distance
23
155
198
Cook's distance
0.00
0.01
0.02
0.03
0.04
0
50
100
150
200
Obs. number
lm(improveform ~ sex + age + +setting + viewenc + improveclasf + improvebod ...