New technology => new pedagogy?

- learning outcomes of different implementations of microcomputer based labs (MBL).

Jonte Bernhard

Linköping University, Campus Norrköping, Norrköping, Sweden

E-mail: jonbe43@liu.se, Homepage: www.itn.liu.se/~jonbe43

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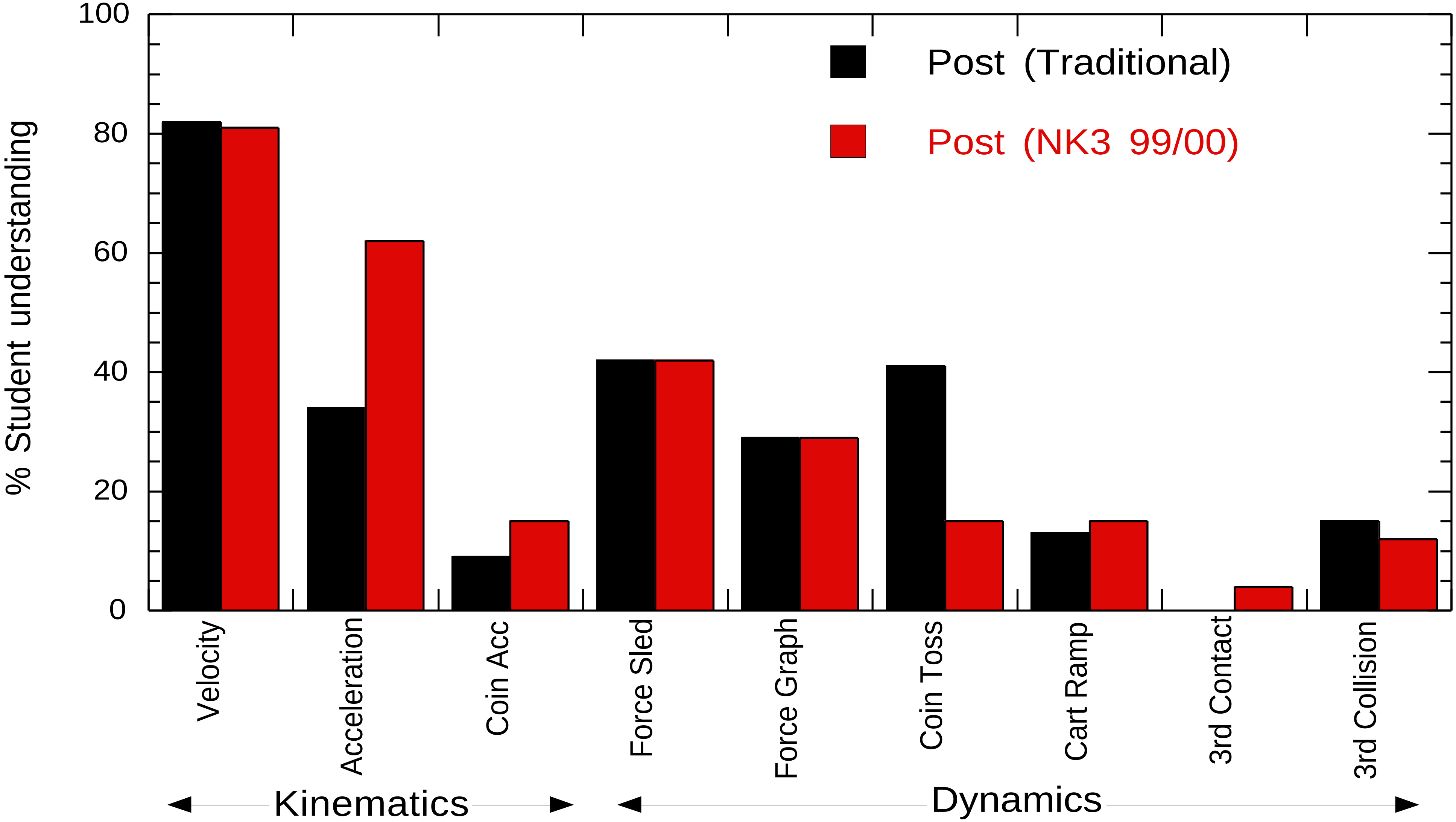
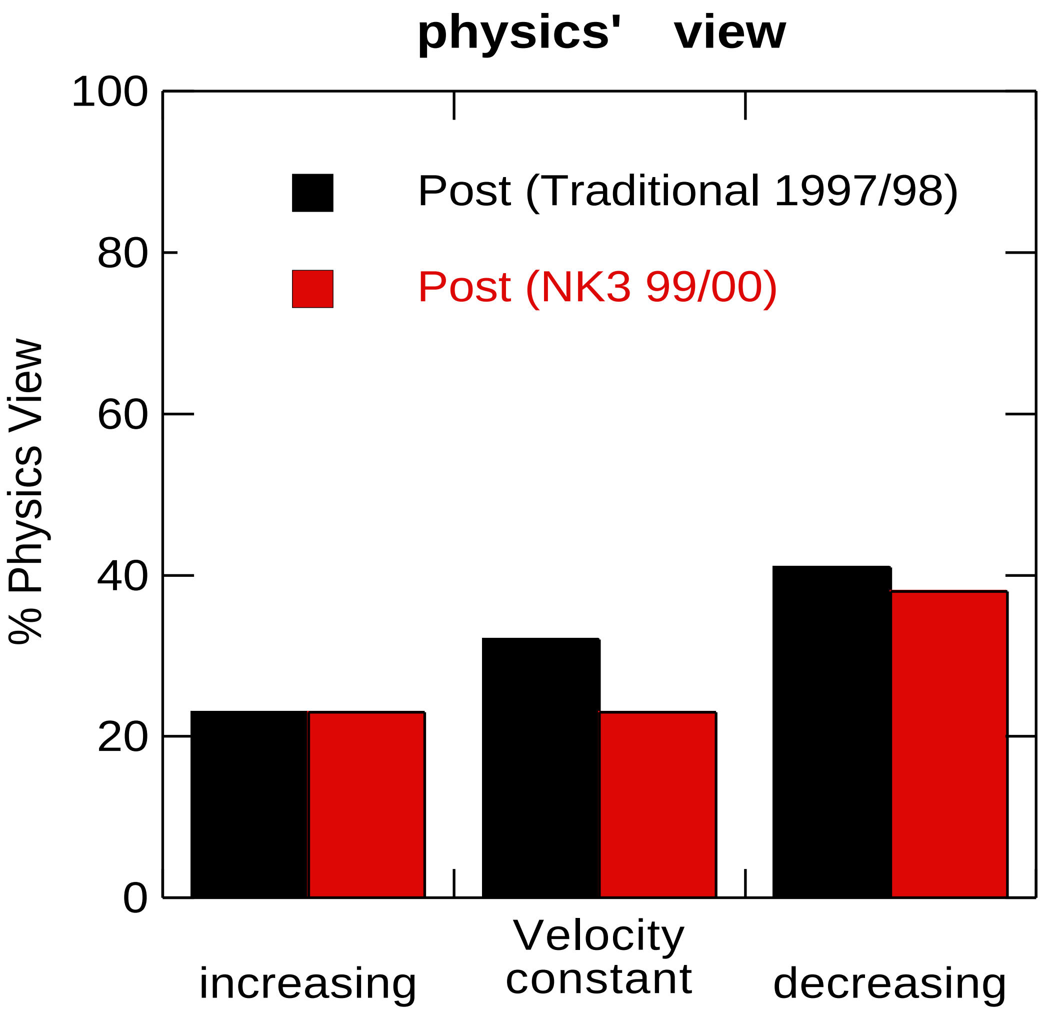
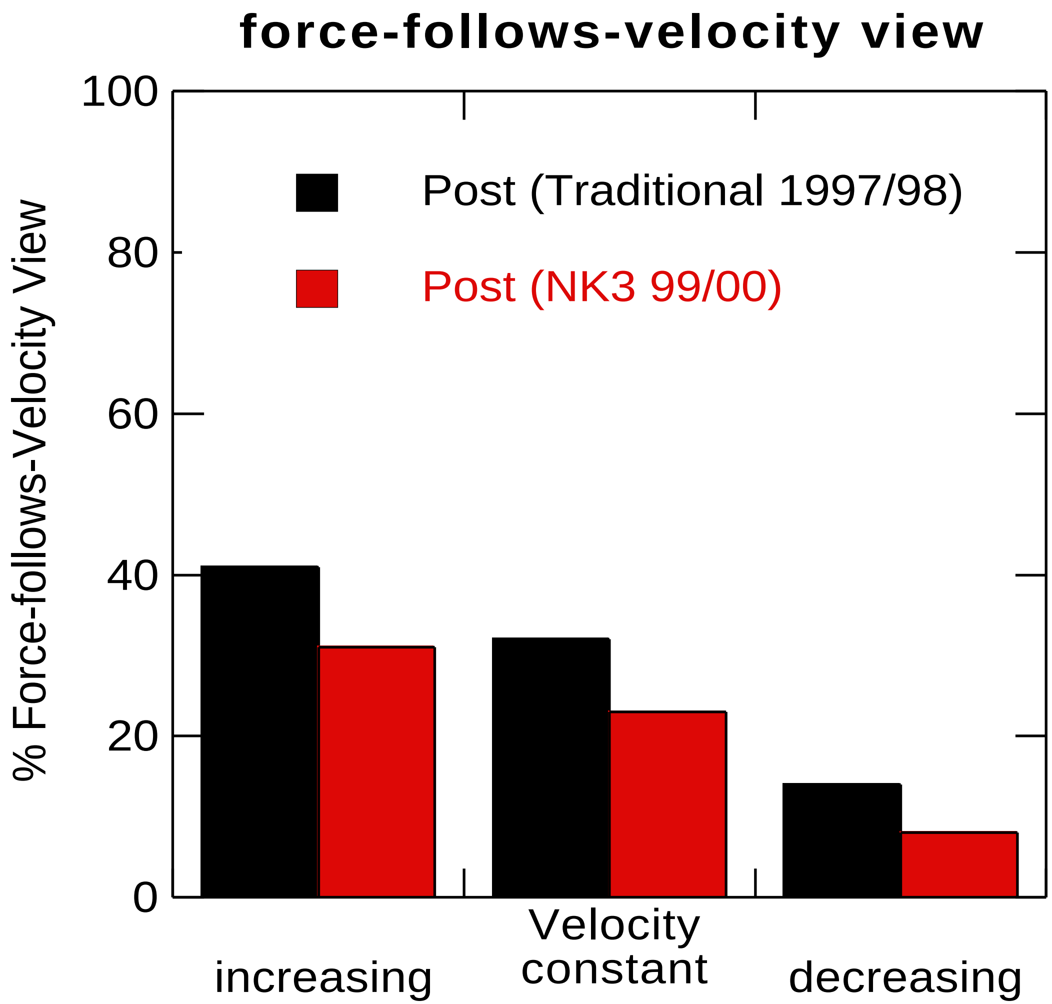
Student understanding after a ”traditional” physics course



Student understanding after a ”traditional” physics course



Student understanding after a ”traditional” physics course



Why?

- 20 years of real-world experience
- strong mental models called (preconceptions / alternative conceptions)
- are not blank slates
- mental models of students must be effectively addressed
- very difficult to change an established model

Some advantages of Microcomputer Based Labs (MBL)

- Real-time display of experimental results and graphs
- Direct connection between the real experiment and the abstract representation
- New types of lab experiments facilitating better student learning can be developed using the educational advantage of MBL
- In MBL students do **real** experiments, not simulated ones.
- To take full advantage of MBL the educational implementation is important, not the technology! Active engagement is important!

Different cases

- an early implementation of MBL-labs (Preservice teachers 1995/96) in a course for preservice science teachers (grade 4-9).
- an full implementation of MBL-labs (Mechanics I 1997/98 for Engineering students) and some other reforms.
- an implementation (Preservice teachers 1998/99) were only the MBL-technology were used but the labs were ”traditional” formula verification labs.
- a revision of Preservice 98/99 (Preservice teachers 99/00) in which the Newton III-lab were revised.
- as comparision the results of traditional courses are included.

Implementation of MBL Case 1 and 2

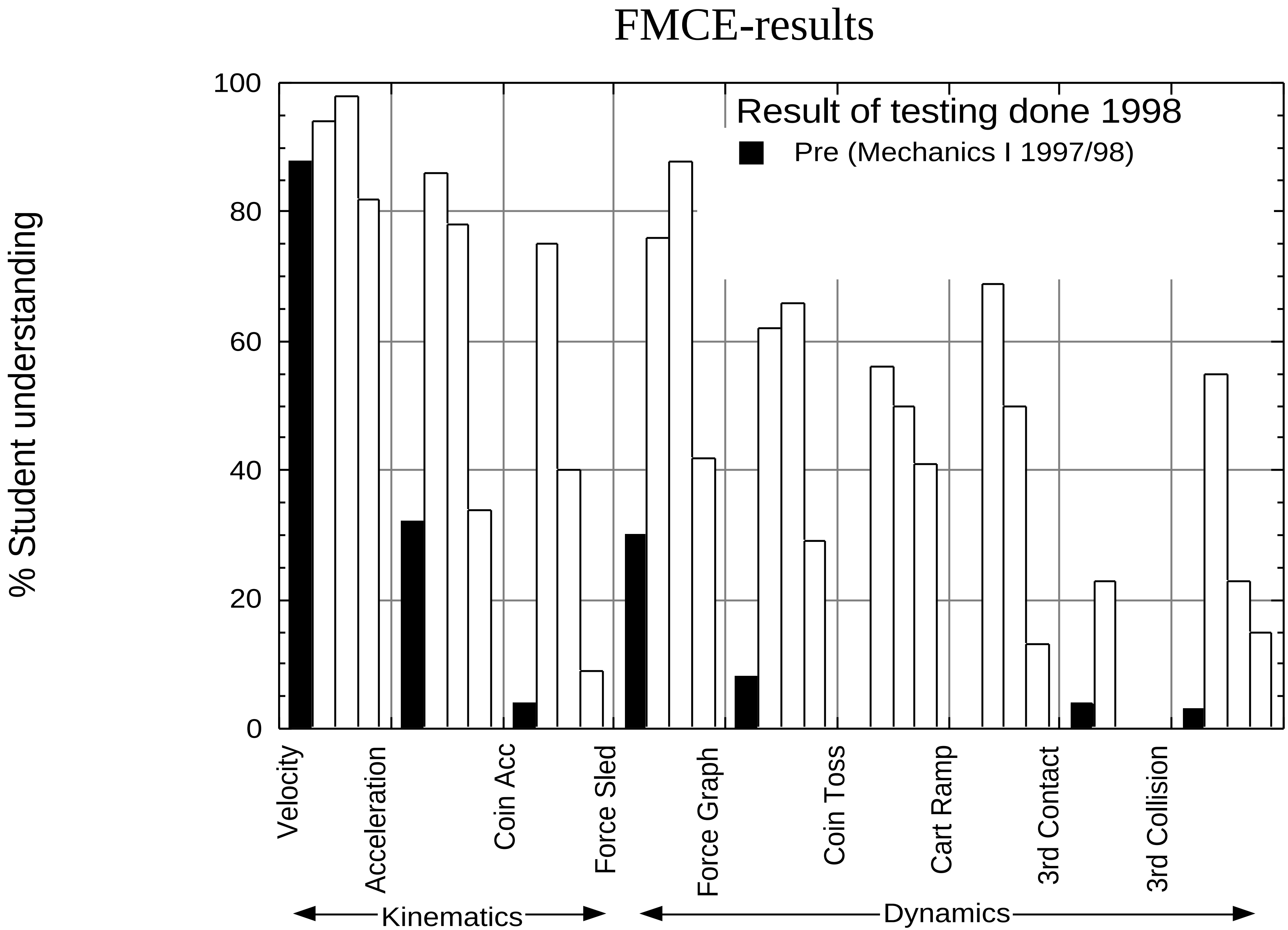
(Preservice teachers 1995/96 and Mechanics I 1997/98)

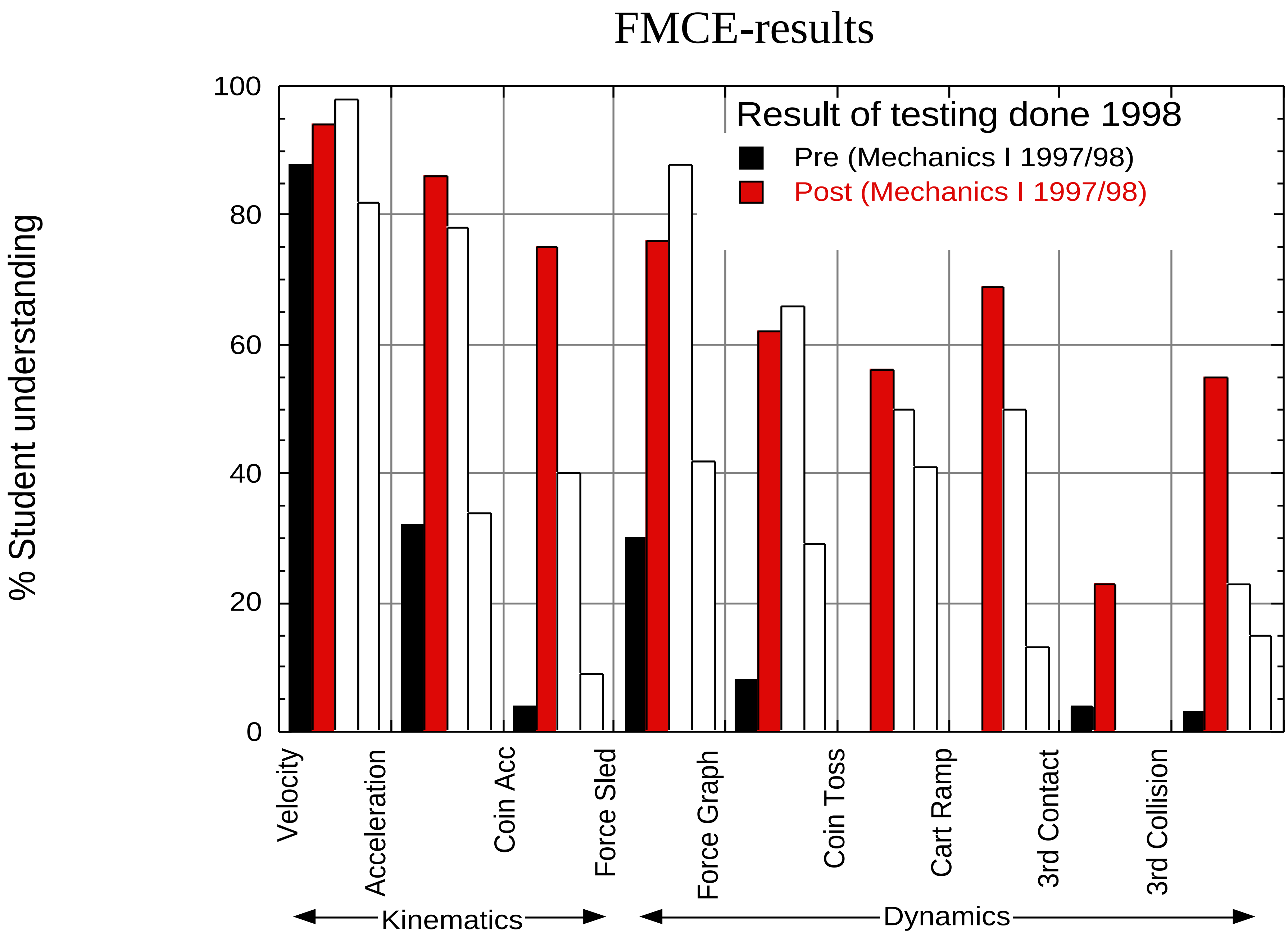
- In both cases were MBL used in active engagement mode and focused on concepts and connections between different concepts. More stress on kinematics than traditional in Sweden.
- students preconceptions were adressed by asking the students to make predictions of the outcomes of all experiments (elicit - confront - resolve)
- students perform the experiment and compare the outcome with the prediction (elicit - confront - resolve) and discuss the result. At this point the the rapid display of the results by the computer in graphical form is of crucial educational value.

Force Concept Inventory

(Mechanics I, Högskolan Dalarna)

Freshman year	Pretest Average	Posttest Average	Gain (G)	Normalised gain (g)
95/96		62% (After advanced Mechanics)		
96/97	52%	64%	12%	25%
97/98 (**)	51%	73%	22%	45%


FMCE-results
Result of testing done 1998
Pre (Mechanics I 1997/98)
% Student understanding
100
80
60
40
20
0
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics


FMCE-results
Result of testing done 1998
Pre (Mechanics I 1997/98)
Post (Mechanics I 1997/98)
% Student understanding
100
80
60
40
20
0
Velocity
Acceleration
Coin Acc
Force Sled
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Cart Ramp
3rd Contact
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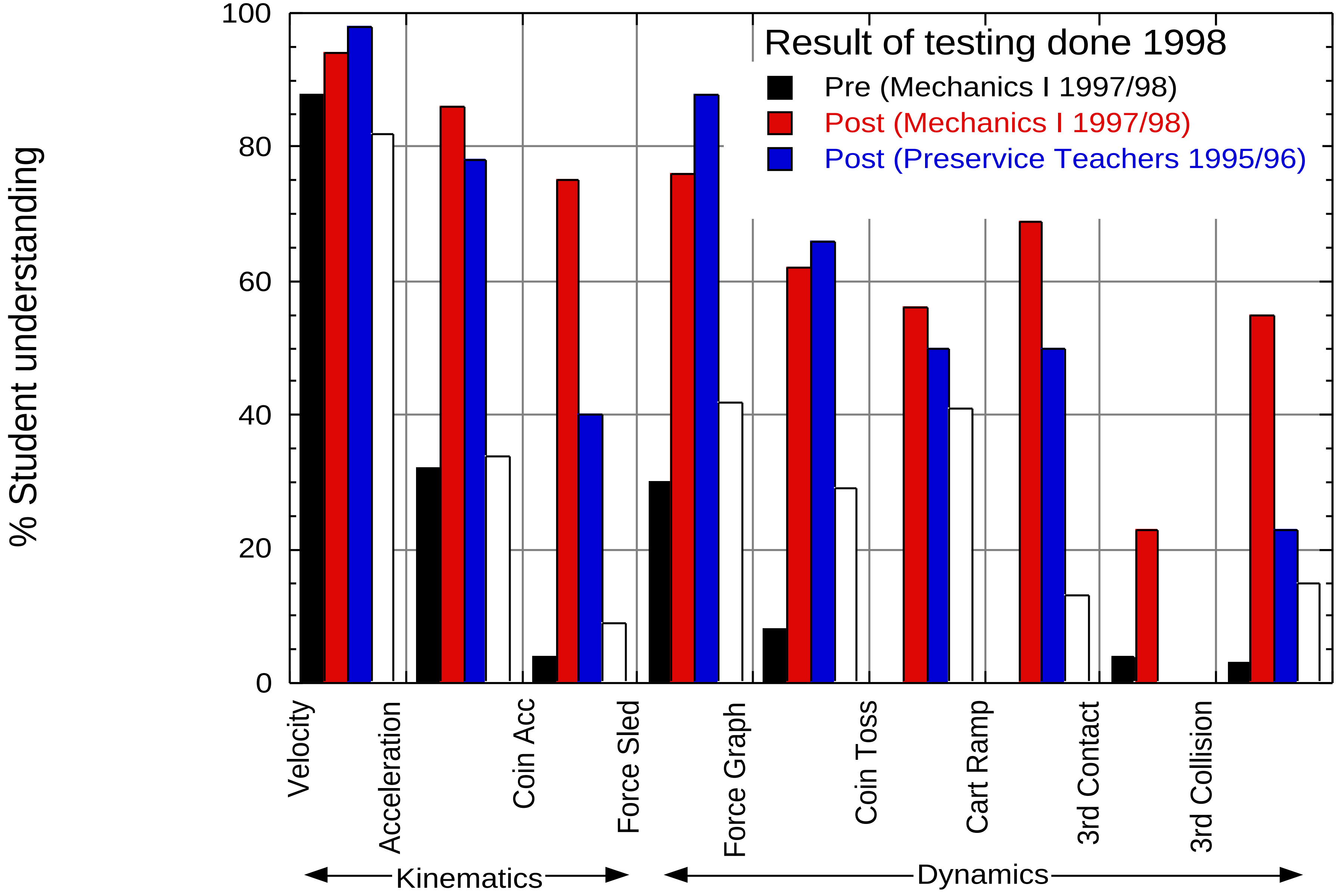
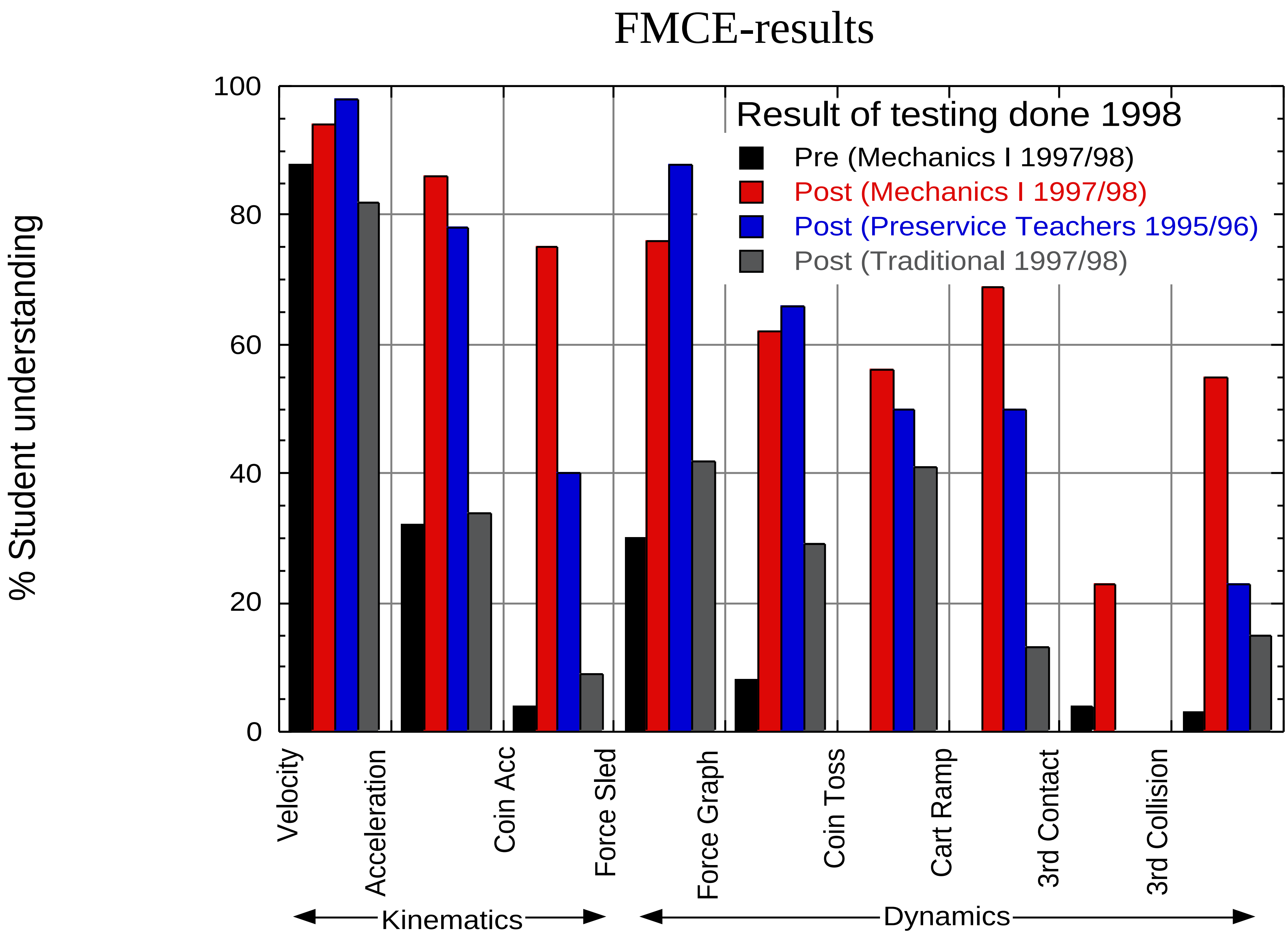
Kinematics
Dynamics

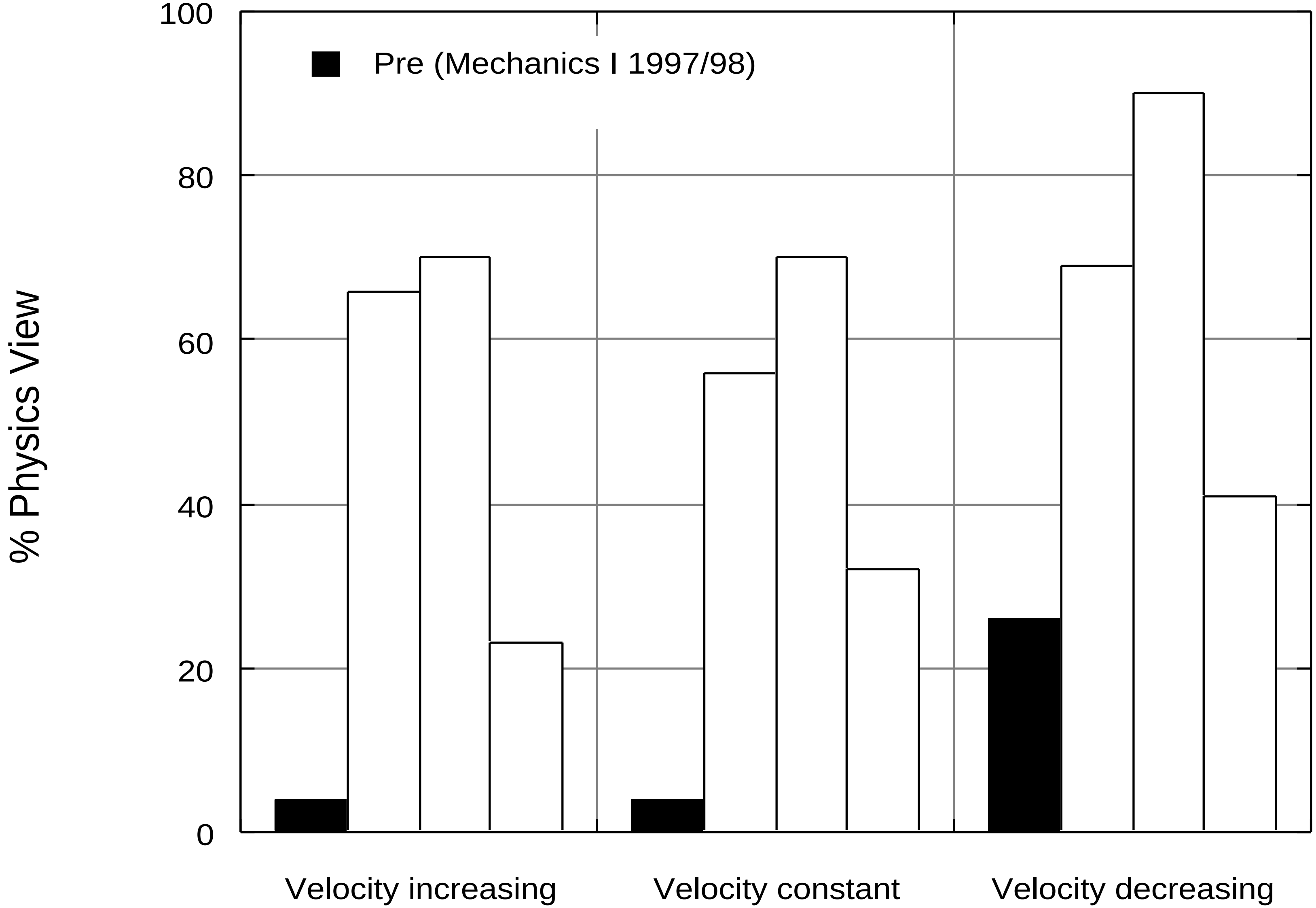
FMCE-results



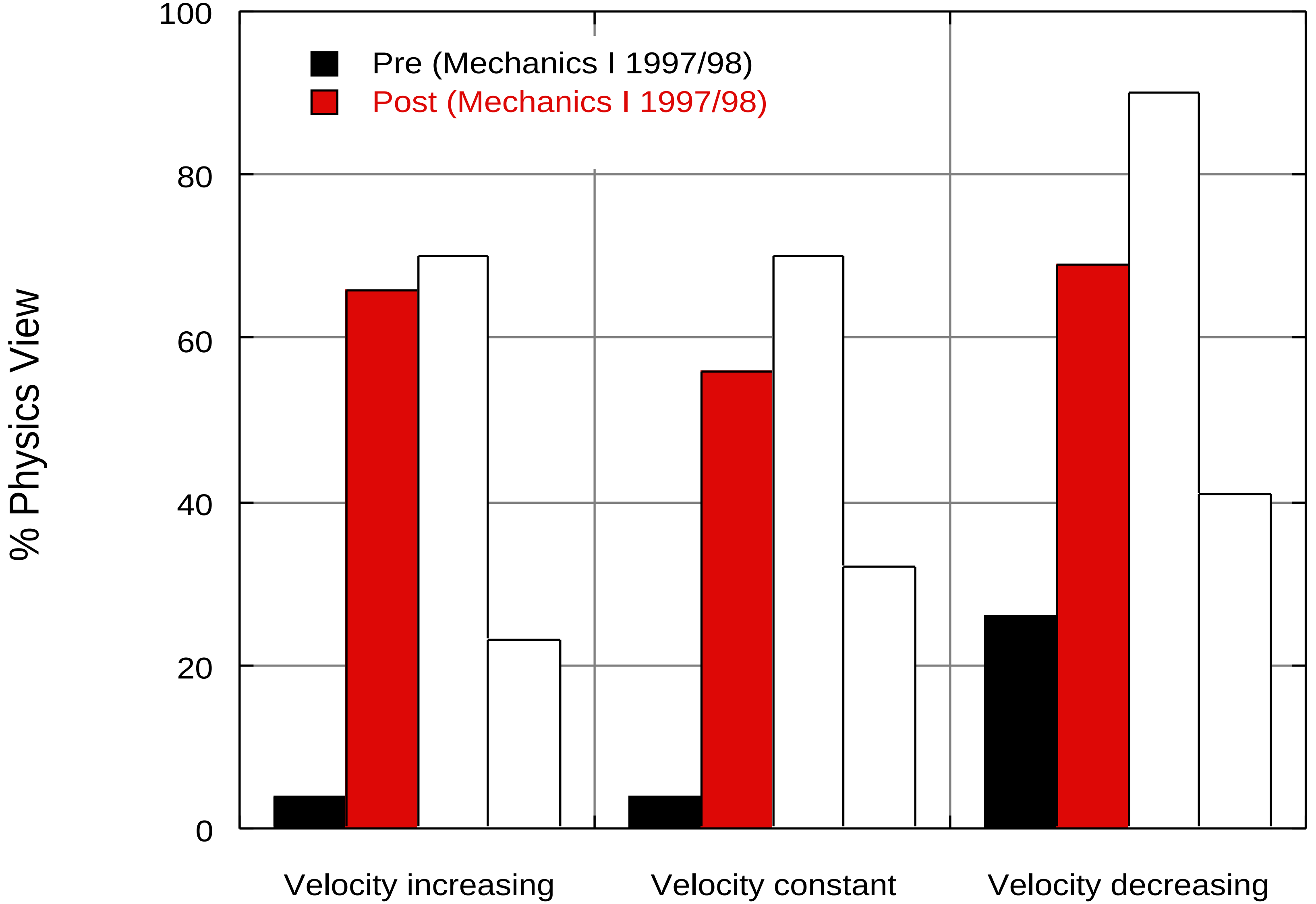


FMCE-results
% Student understanding
100
80
60
40
20
0
Result of testing done 1998
Pre (Mechanics I 1997/98)
Post (Mechanics I 1997/98)
Post (Preservice Teachers 1995/96)
Post (Traditional 1997/98)
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics

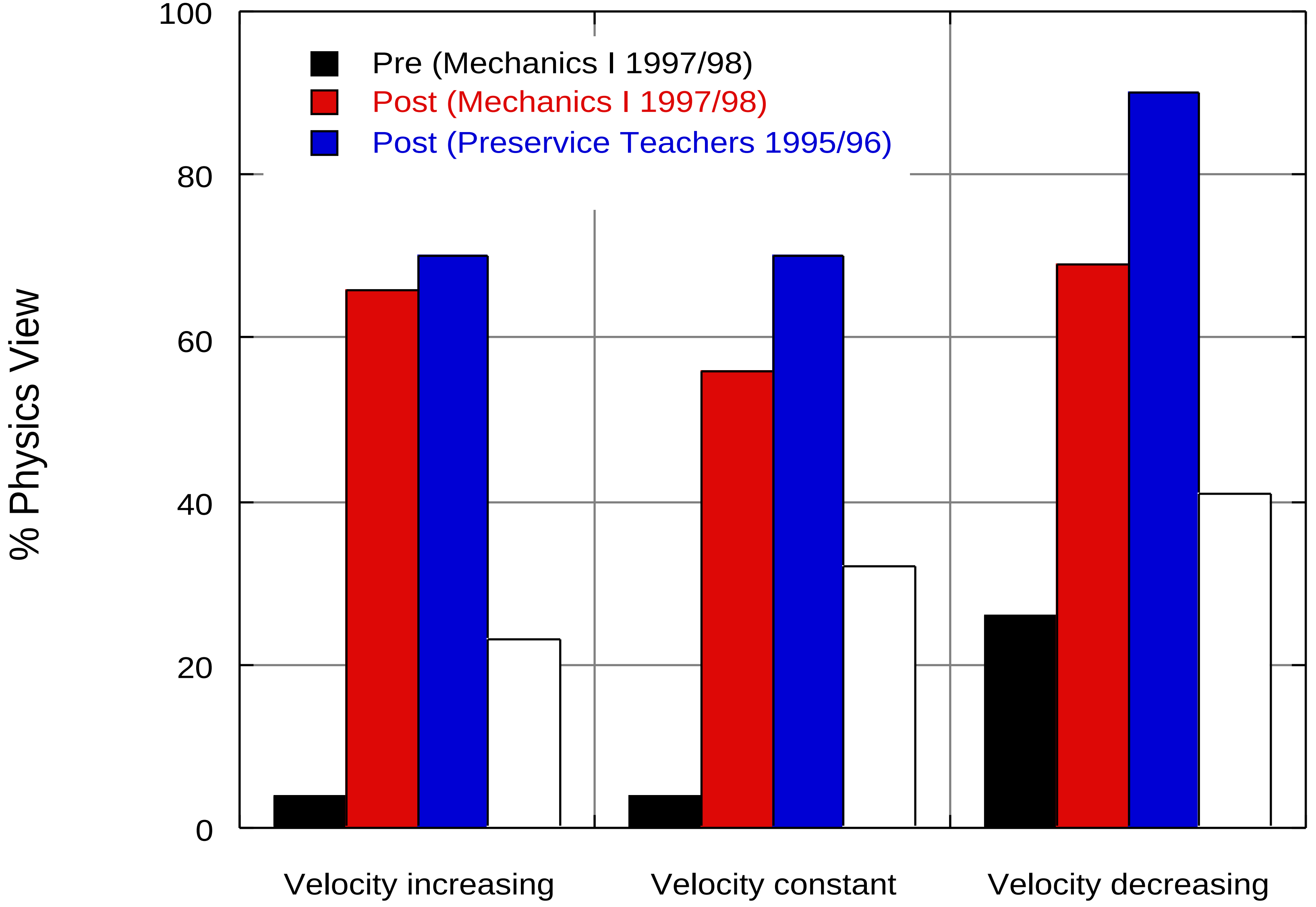
Fraction of Physicists' view assigned from FMCE-data



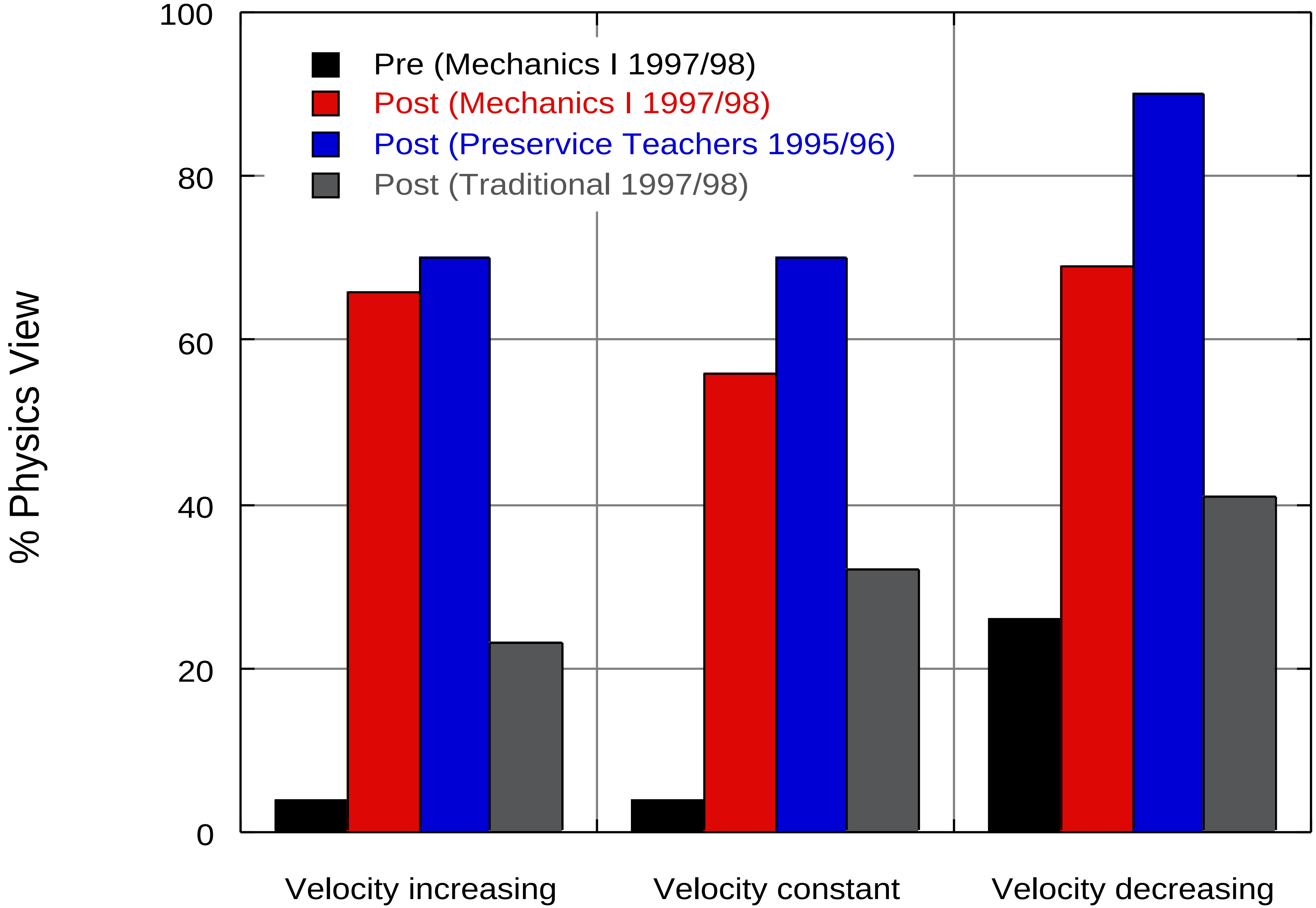
Fraction of Physicists' view assigned from FMCE-data



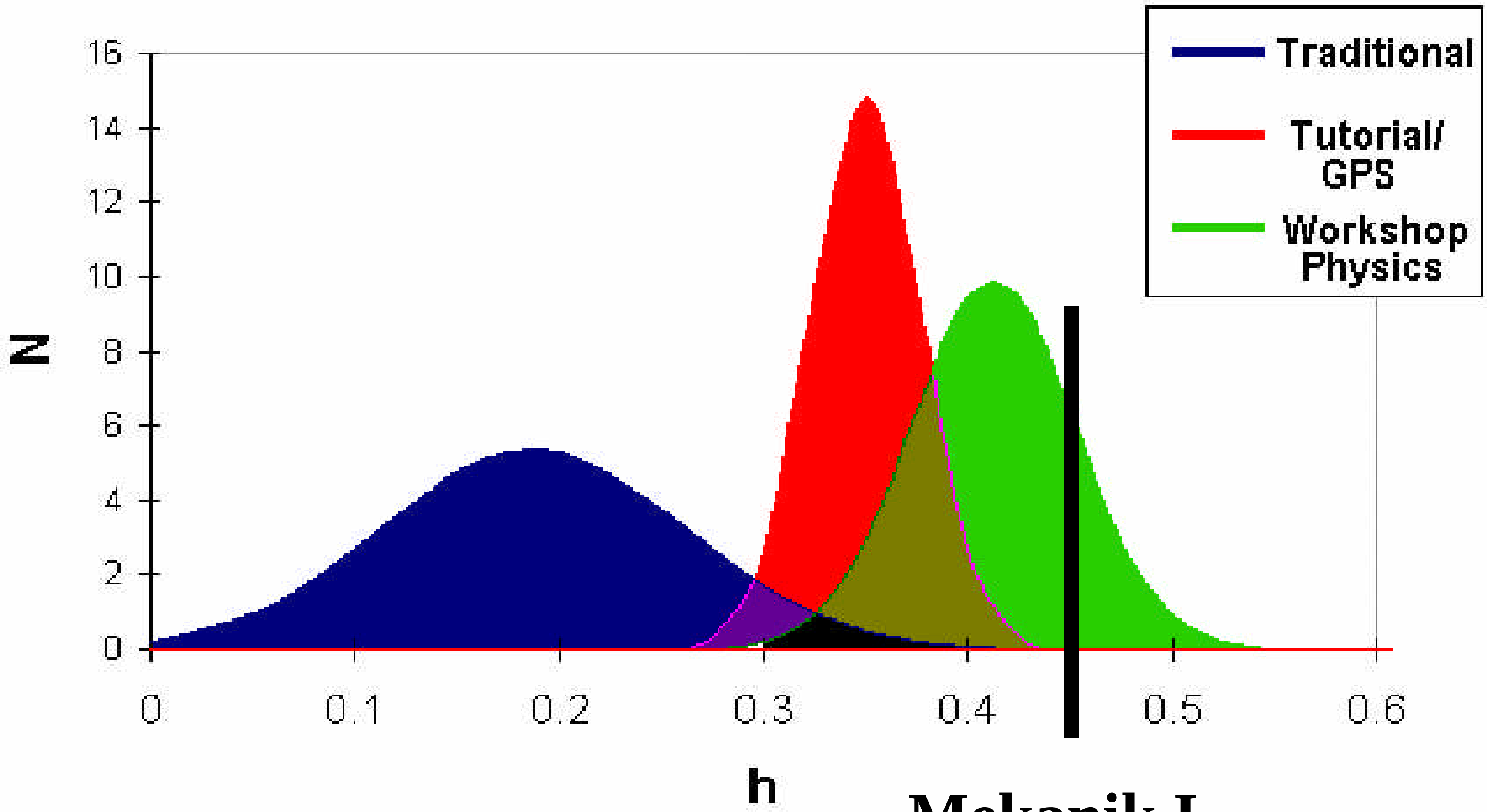
Fraction of Physicists' view assigned from FMCE-data



Fraction of Physicists' view assigned from FMCE-data
(R Thorntons Conceptual Dynamics method)



Teaching Method	**Normalised gain (FCI)**	**Reference**
Workshop physics	41%	Saul and Redish 1998
Tutorials in Introductory physics (McDermott style)	35%	Saul and Redish 1998
Group Problem Solving	34%	Saul and Redish 1998
Preservice	~42%	This study
Mechanics I (1997/98)	45%	This study
Traditional	16%	Saul and Redish 1998



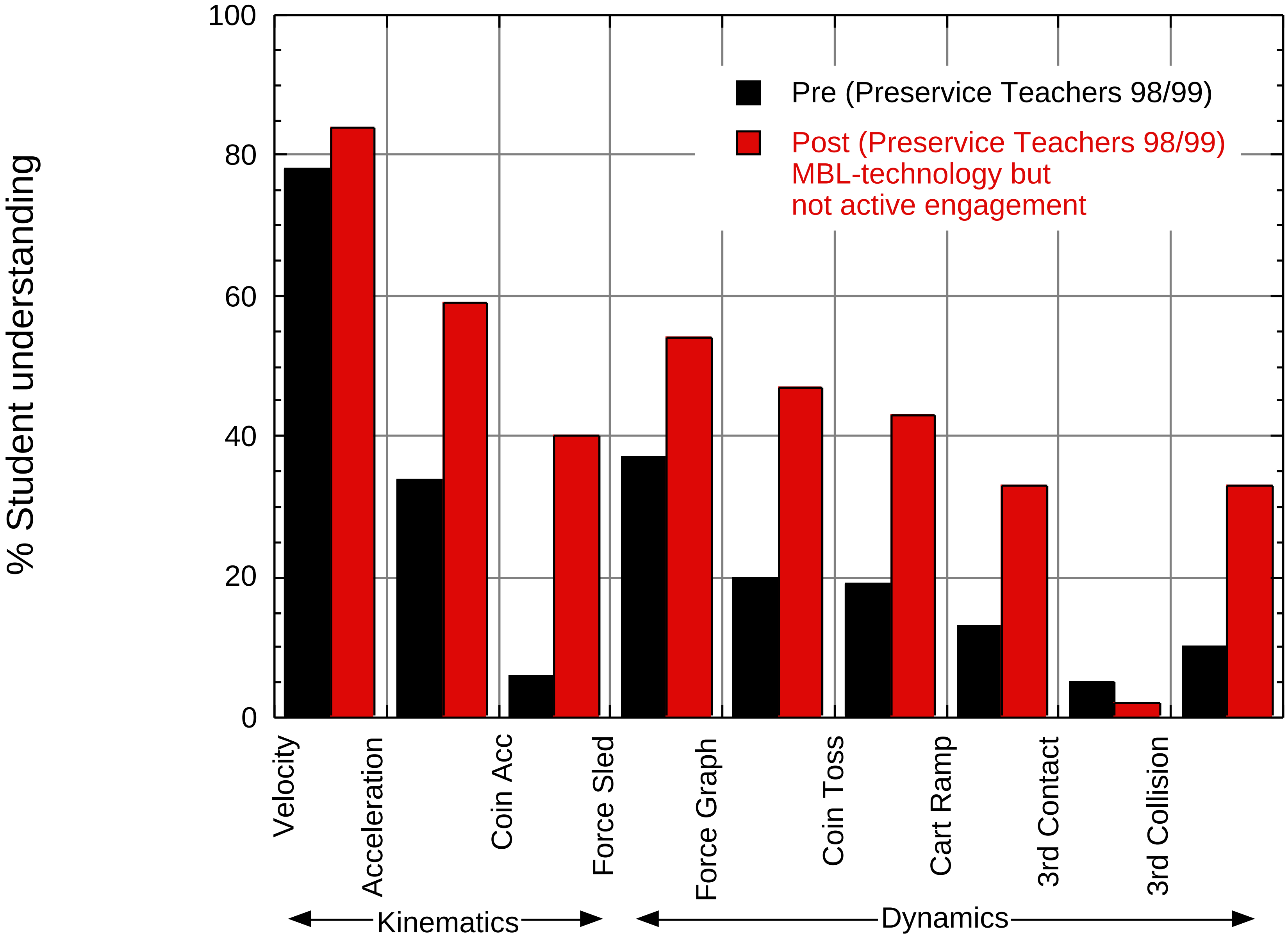
16
14
12
10
8
6
4
2
0
N
0
0.1
0.2
0.3
0.4
0.5
0.6
h
Traditional
Tutorial/
GPS
Workshop
Physics

Mekanik I

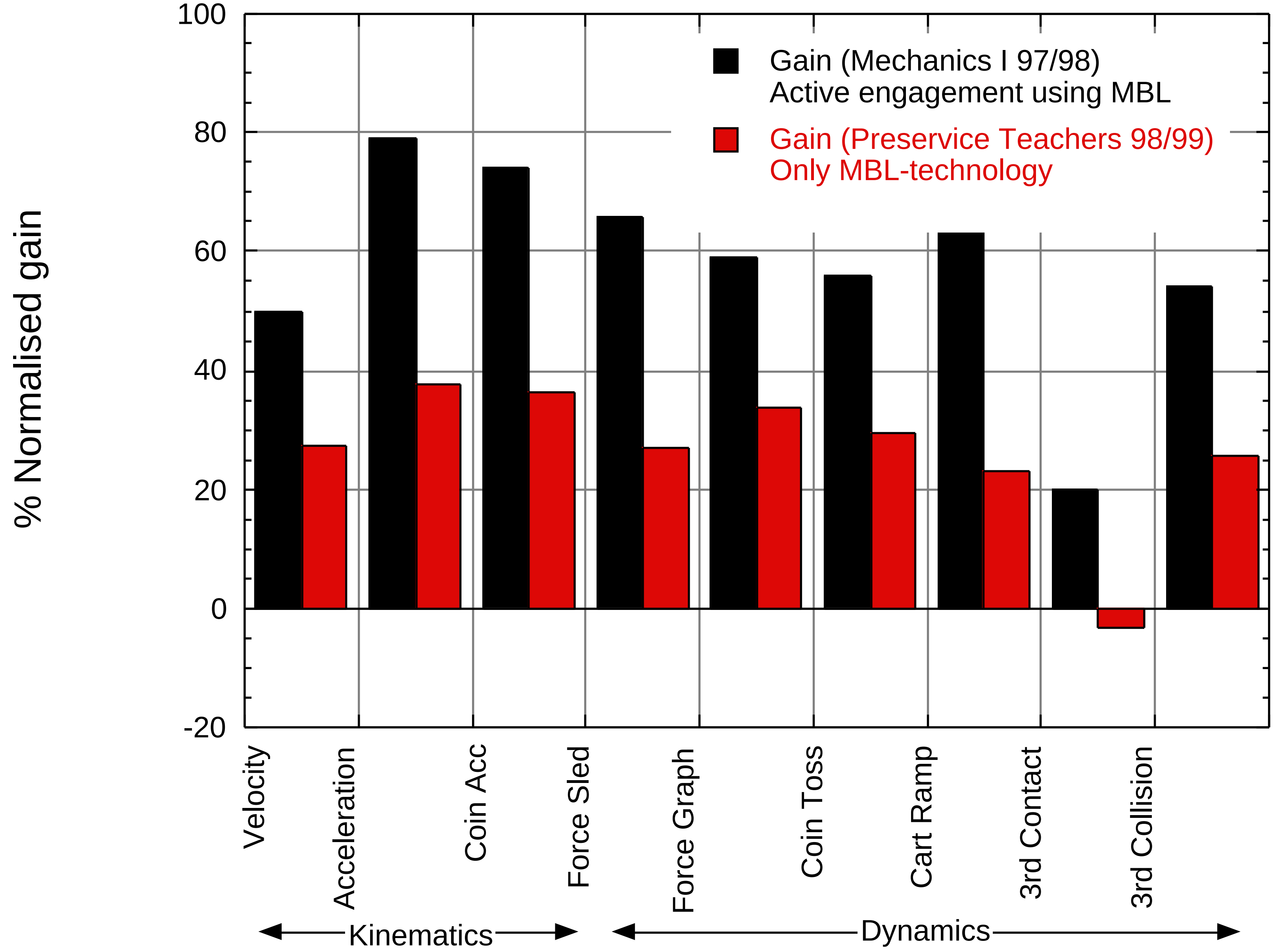
Implementation of MBL

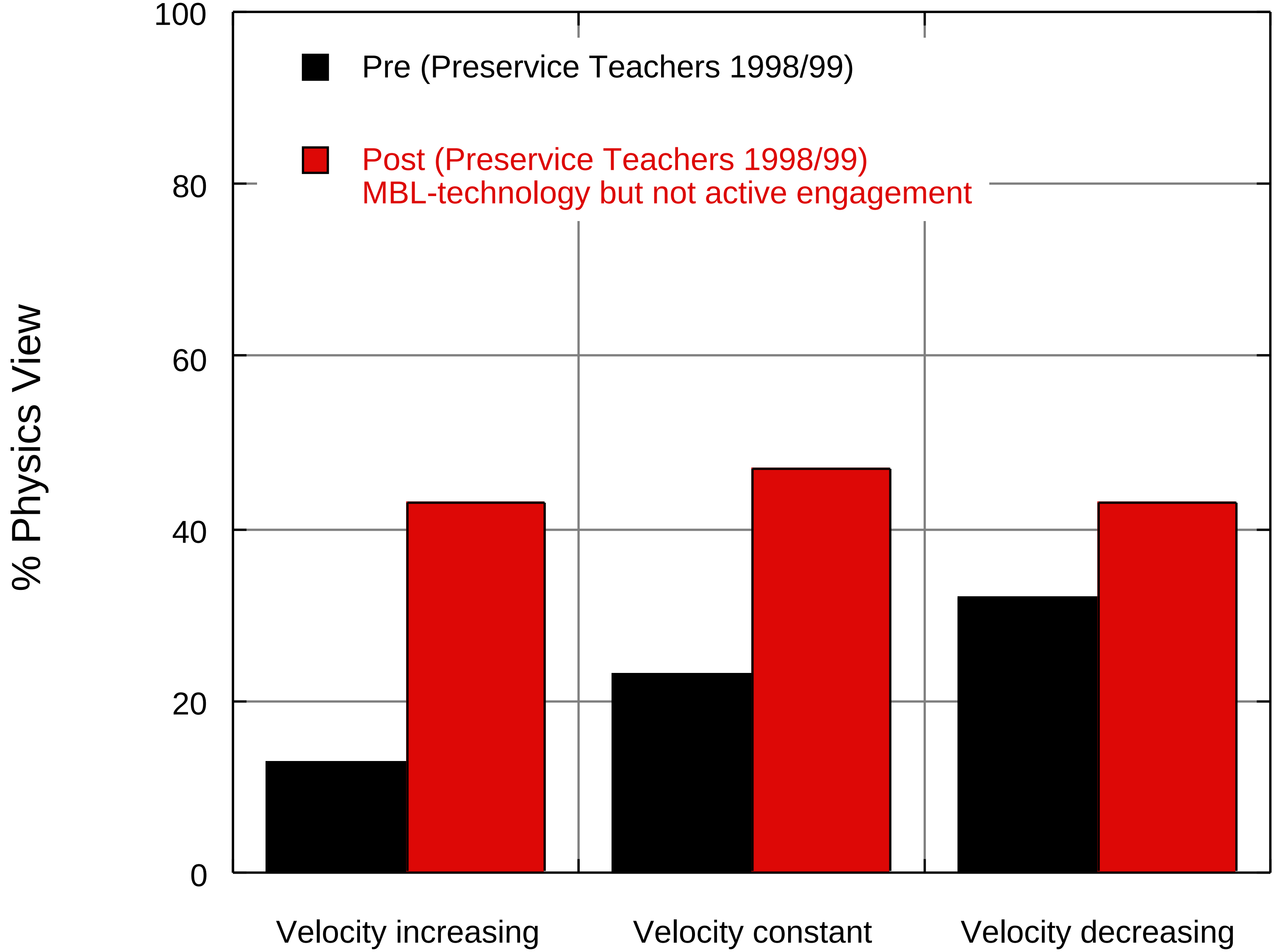
Case 3 (Preservice teachers 1998/99)

- MBL-technology were used in the labs.
- the original labs were locally ”improved” and transformed into formula verifaction labs.
- the students were not asked to do any predictions.
- no lab on kinematics.

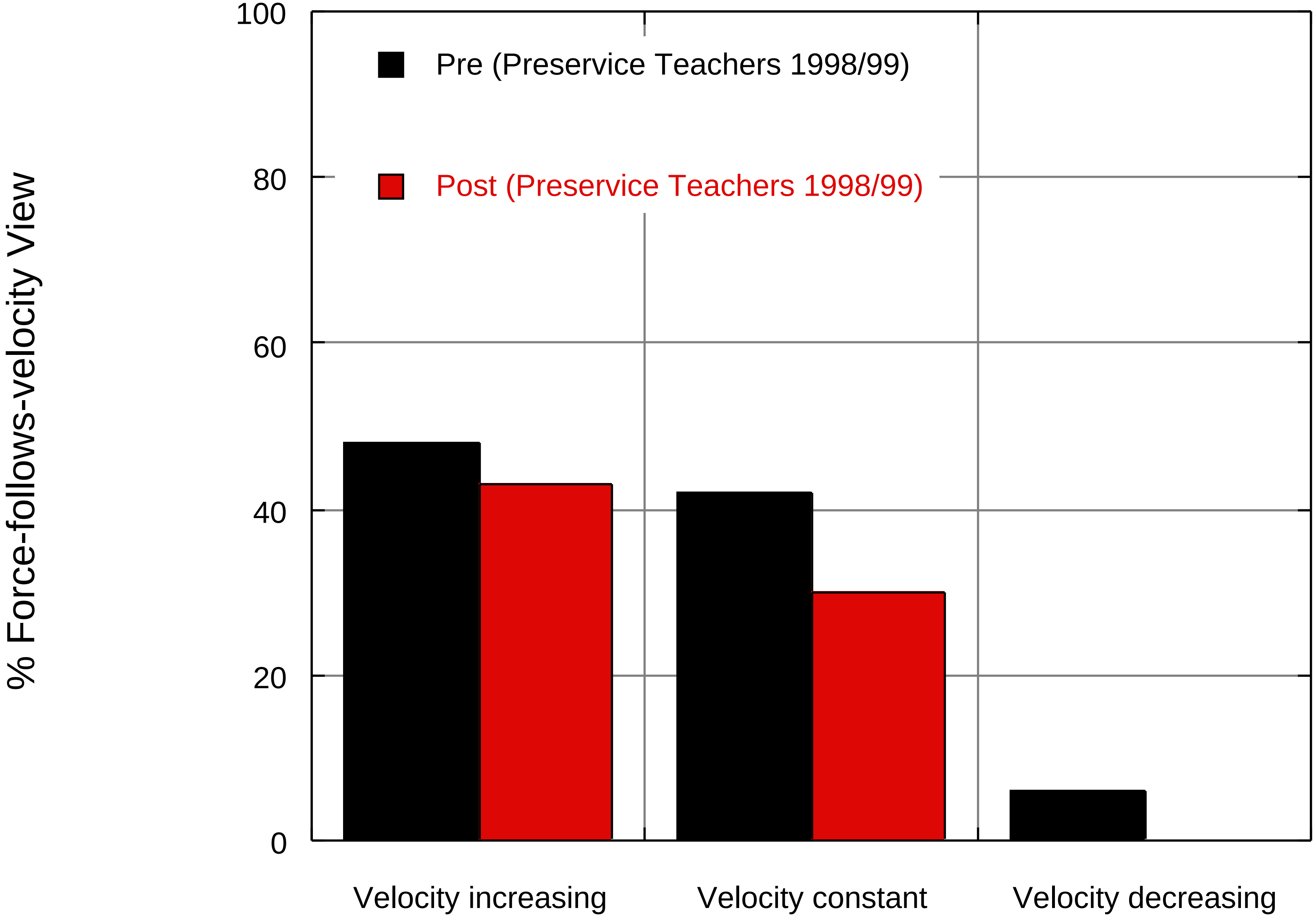


% Student understanding
100
80
60
40
20
0
Pre (Preservice Teachers 98/99)
Post (Preservice Teachers 98/99)
MBL-technology but
not active engagement
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics


% Normalised gain
100
80
60
40
20
0
-20
Gain (Mechanics I 97/98)
Active engagement using MBL
Gain (Preservice Teachers 98/99)
Only MBL-technology
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics



% Physics View
100
80
60
40
20
0
Pre (Preservice Teachers 1998/99)
Post (Preservice Teachers 1998/99)
MBL-technology but not active engagement
Velocity increasing
Velocity constant
Velocity decreasing

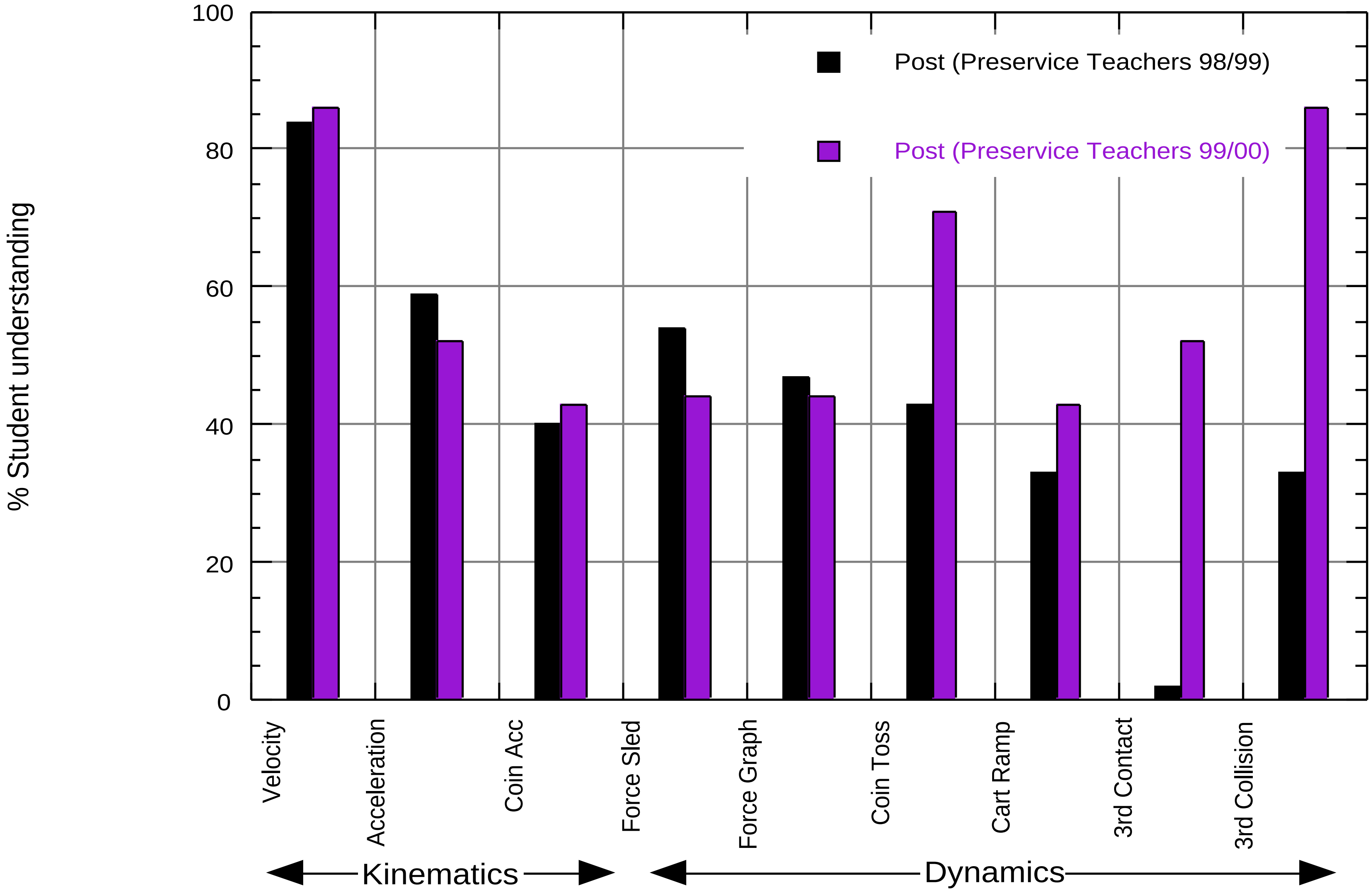


% Force-follows-velocity View
100
80
60
40
20
0
Pre (Preservice Teachers 1998/99)
Post (Preservice Teachers 1998/99)
Velocity increasing
Velocity constant
Velocity decreasing

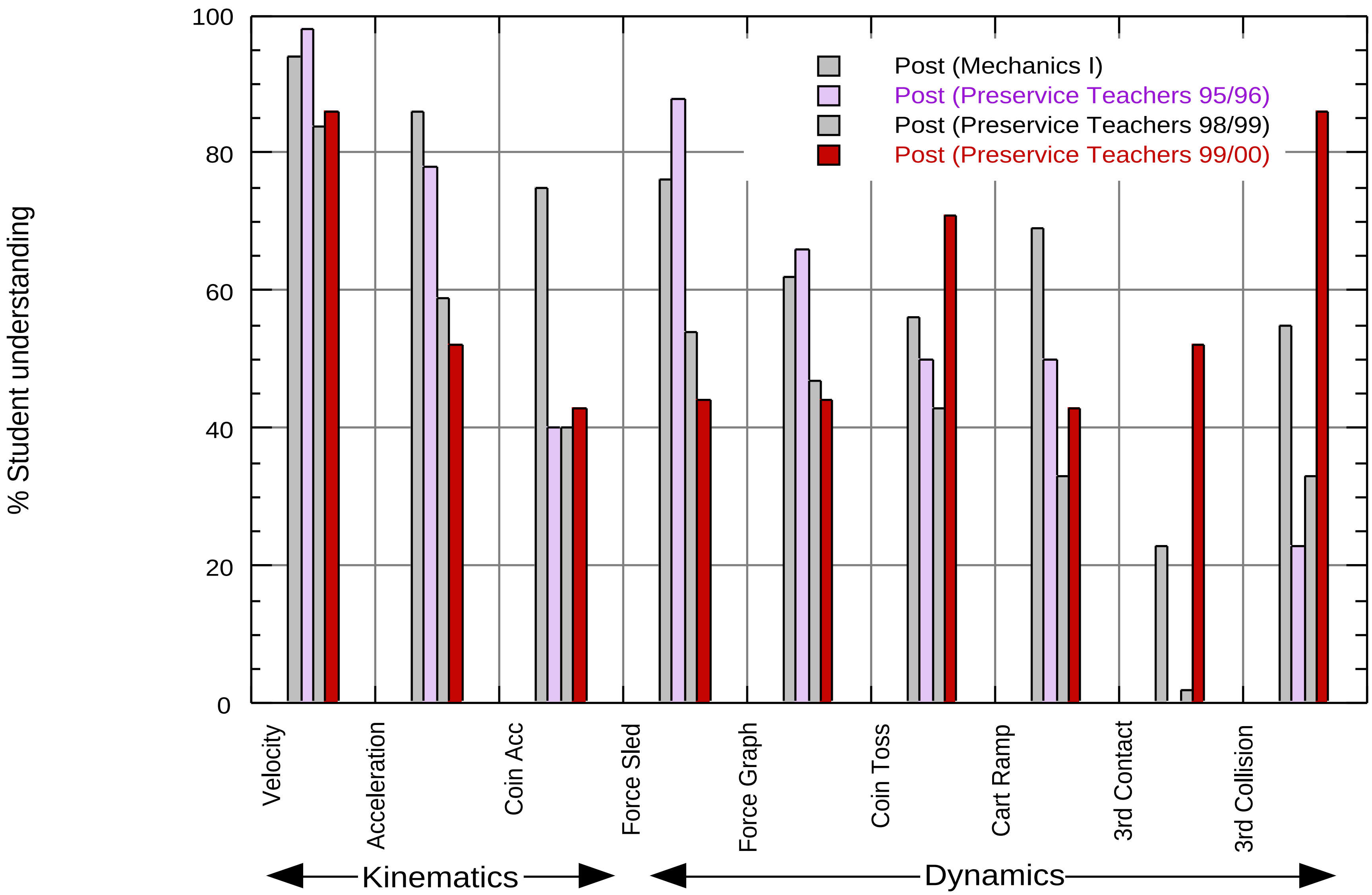
Implementation of MBL

Case 4 (Preservice teachers 1999/00)

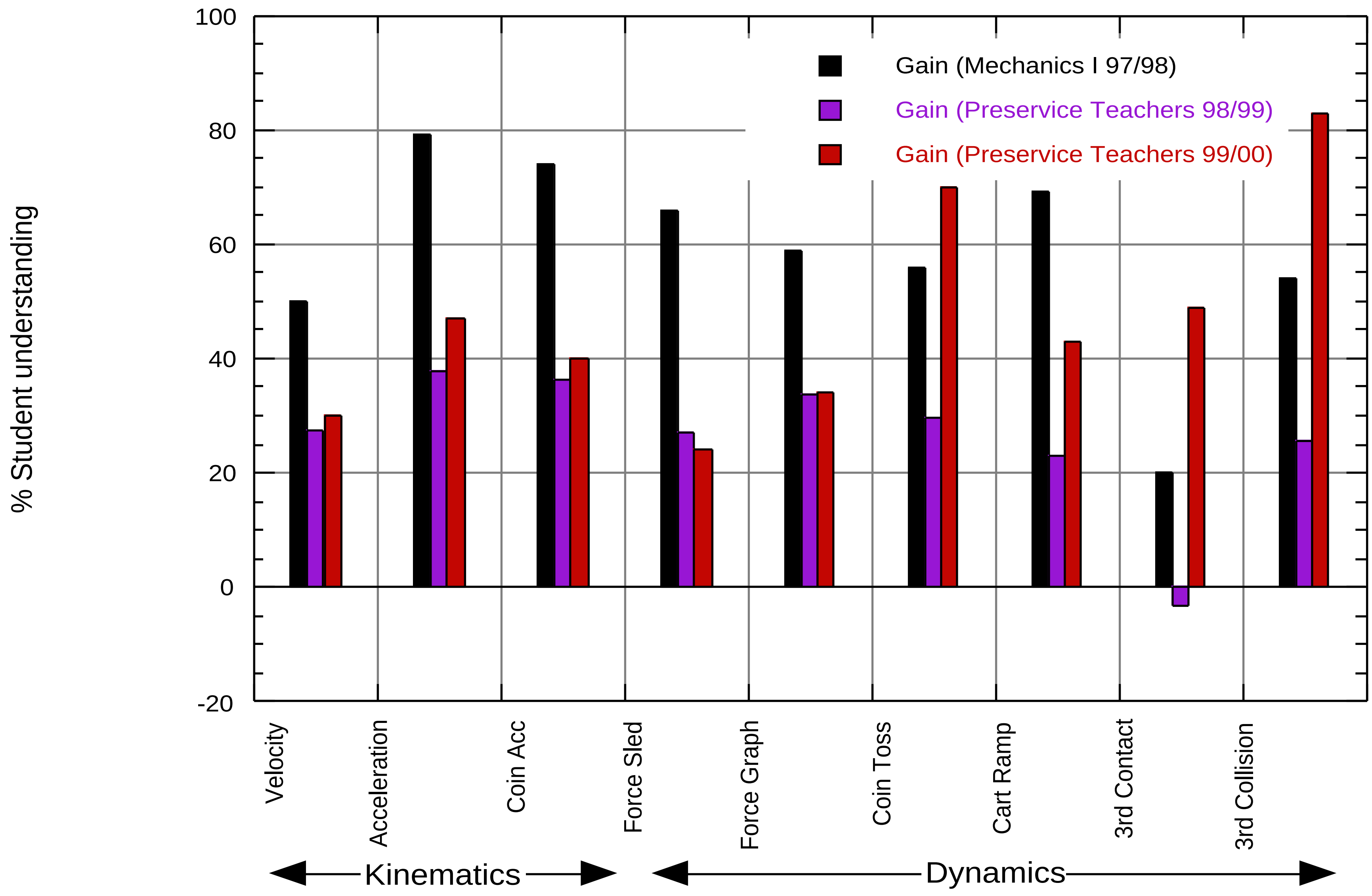
- Similar to Case 3
- the “Newton III-lab” were changed from “formula verification” to “active engagement”



100
80
60
40
20
0
% Student understanding
Post (Preservice Teachers 98/99)
Post (Preservice Teachers 99/00)
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics



100
80
60
40
20
0
% Student understanding
Post (Mechanics I)
Post (Preservice Teachers 95/96)
Post (Preservice Teachers 98/99)
Post (Preservice Teachers 99/00)
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics



% Student understanding
100
80
60
40
20
0
-20
Gain (Mechanics I 97/98)
Gain (Preservice Teachers 98/99)
Gain (Preservice Teachers 99/00)
Velocity
Acceleration
Coin Acc
Force Sled
Force Graph
Coin Toss
Cart Ramp
3rd Contact
3rd Collision
Kinematics
Dynamics

FCI-results

Course	Year	Main student body	”Method”	Pretest Average (FCI)	Posttest Average (FCI)	Gain (G) (FCI)	Normalised gain (g) (FCI)
Preservice (Case 1)	95/96	Preservice Science Teachers (grade 4-9)	Early MBL implementation	~50%	71%	~21%	~42%
Mechanics I (Case 2)	97/98	Engineering	Full MBL + some other reforms	51%	73%	22%	45%
Preservice (Case 3)	98/99	Preservice Science Teachers (grade 4-9)	Only MBL-technology NOT MBL-pedagogy	49%	65%	16%	31%
Preservice (Case 4)	99/00	Preservice Science Teachers (grade 4-9)	Partial MBL-pedagogy	35%	67%	32%	49%
Traditional	97/98	Engineering	Traditional	~50%	58%	~8%	~16%

FMCE-results

Course	**Year**	**Main student body**	**”Method”**	**Pretest Average (FMCE)**	**Posttest Average (FMCE)**	**Gain (G) (FMCE)**	**Normalised gain (g) (FMCE)**
Mechanics I (Case 2)	97/98	Engineering	Full MBL + some other reforms	29%	72%	43%	61%
Preservice (Case 3)	98/99	Preservice Science Teachers (grade 4-9)	Only MBL-technology NOT MBL-pedagogy	33%	53%	20%	30%
Preservice (Case 4)	99/00	Preservice Science Teachers (grade 4-9)	Partial MBL-pedagogy	27%	62%	35%	49%

RESULTS
Case 1 and 2

- the students have got a much better conceptual understanding of mechanics than students in traditionally taught courses.
- a high fraction of the students have acquired a Newtonian view and a low fraction of students hold a force-follows-velocity view after instruction.
- the gains are comparable to well known innovative courses in USA.
- the students in Mechanics I performed significantly better on traditional problems in the final exam.
- male and female students got the same normalised gains in Mechanics I

Case 3

- the students did not perform as well as in case 1 and 2 but somewhat better than students in traditionally taught courses.
- almost the same fraction of students holding the force-follows-velocity view after instruction as before instruction. By eliminating the active engagement part from the labs the ”weak” students were not reached.
- big difference in gains between male (higher) and female (lower) students.

Case 4

- the results are similar to case 3, but somewhat better.
- much better results for Newton III.
- the results for Newton III is better than case 2.

CONCLUSIONS

- Microcomputer Based Labs (MBL) in an active engagement approach is an effective way of fostering conceptual change (concept substitution) in mechanics.
- MBL is good both for pre-service teachers and engineering students.
- The MBL-approach can be misunderstood and implemented as a technology only approach.
- When implemented without sound pedagogy MBL is only marginally better than ”traditional” teaching.