

Quantum Computing Paradigms in Modern Physics and Engineering

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Abstract 6WXGHQWV OHDUQ HIIHFWLYHO\ LQ D

OHDUQLQJ HQYLURQPHQW
ZLWK D VXLWDEOH WHDFKLQJ DSSURDFK WKDW
PDWFKHV WKHLU OHDUQLQJ SUHIHUHQFHV 7KH PDLQ
REMHFWLYH RI WKH VWXG\ LV WR H[DPLQH WKH
OHDUQLQJ SUHIHUHQFHV DPRQJVW WKH VWXGHQWV
LQ WKH 6FLHQFH DQG 7HFKQRORJ\ 6 7 DQG 6RFLDO
6FLHQFH66 ILHOGV RI VWXG\ DW WKH
8QLYHUVLWL7HNQRORJL0DUD8L703XODX3LQDQJ7KHPH
DVXUHPHQW
LQVWUXPHQWLVEDVHGRQWKH'XQQDQG'XQQ\HQUQLQJ
J6W\OHVZKLFK
PHDVXUHILYHHOHPHQWVRIOHDUQLQJ\OHVHQYLU
RPHQWDOVRFRLRORJLFDO HPRWLRQDO
SK\VLRRORJLFDO DQG SV\FKRORJLFDO
4XHVWLRQQDLUHV DUH GLVWULEXWHG DPRQJVW
XQGHUJUDGXDWLV LQ WKH)DFXOW\ RI 0HFKDQLFDQ
(QJLQHHULQJ)DQJ)DFXOW\RI%XLVQHVV0DQJPHQW7
KHUHVSRQGHQWV FRPSULVH RI GLSORPD VWXGHQWV
RI WKH)DFXOW\ RI 0HFKDQLFDQ (QJLQHHULQJ DQG
GHJUHH VWXGHQWV RI WKH)DFXOW\ RI %XLVQHVV
0DQJPHQW 7KH UHVXOWV LQGLFDWH WKDW ERWK 6
7 DQG 66 VWXGHQWV VKDUH D VLPLODU OHDUQLQJ
SUHIHUHQFHV RQ WKH HQYLURQPHQWDO DVSHFW
HPRWLRQDO SUHIHUHQFHV PRWLYDWRQDO OHYHO
OHDUQLQJ UHVSRQVLELOLW\
SHUVLVWHQWOHYHOLQOHDUQLQJ)DQGOHDUQLQJ\WV
XFWXUH0RVWRIWKH 7
VWXGHQWV)DFXOW\RI%XLVQHVV0DQJPHQW
UVDQGWKHPDMRULW\RI66
VWXGHQWV)DFXOW\RI%XLVQHVV0DQJPHQW
7DQG66VWXGHQWV)DFXOW\RI%XLVQHVV0DQJPHQW
DVYLXDOOHDUQHUVSUHIHUHQFHVWREHLQDQDFWLYH
PRELQW\LDUHQD[LQJ DQG HQMR\QJ PRG ZLWK
VRPH OLJKW RI UHIHVKPHQWV GXULQJ WKH
OHDUQLQJ)DFXOW\RI%XLVQHVV0DQJPHQW
DFWHULVWLVFLQOHDUQLQJ 2EYLRXVO\WKH6
7VWXGHQWV)DFXOW\RI%XLVQHVV0DQJPHQW
QW ZKHUHDV WKH 66 VWXGHQWV DUH ULJKW EUDLQ
GRPLQDQW 7KH ILQGLQJ
KLJKOLJKWHGKDWERWKDFWHJRWLVVWXGHQWV
H[KLELWHGVLPLQDUOHDUQLQJ
SUHIHUHQFHVH[FHSWRQSV\FKRORJLFDOSUHIHUHQFH
V

Keywords 2/HDUQLQJ)DFXOW\RI%XLVQHVV0DQJPHQW
QJLQHHULQJ)DFXOW\RI%XLVQHVV0DQJPHQW
WHDFKLQJ)DFXOW\RI%XLVQHVV0DQJPHQW
OVFLHQFH

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7 KLJKHU OHDUQLQJ LQVWLWXWLRQV SURJUDPV
DUH FRPPRQ\
GLYLGHG LQWR WZR GLIIHUHQW ILHOGV 6
7 DQG 66 6 7 FRYHUV PHGLFDO
SKDUPDFHXWLFDO KHDOWK VFLHQFH
HQJLQHHULQJ
DSSOLHG)DFXOW\RI%XLVQHVV0DQJPHQW
HWFZKHUHDV66FRYHUV
PDQDJPHQWDFFRXQWDF\ILQDQDFHEDQNLQJDUWV
KXPDQLWLV UHWDLOLQJ PDUNHWLQJ LQWHULRU
GHVLQJ SV\FKRORJLVW
DUFKLWHFWXUHFRQVXOWDQWODZKXPDQHUVRXU
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KRWHOPDQJPHQW)DFXOW\RI%XLVQHVV0DQJPHQW

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RI 0HFKDQLFDQ (QJLQHHULQJ)DQJ)DFXOW\RI%XLVQHVV0DQJPHQW
(QJLQHHULQJ)DQJ)DFXOW\RI%XLVQHVV0DQJPHQW
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,Q JHQHUDO 66 VWXGHQWV PD\ IRFXV RQ IDFW
DQG GDWD DQG GHDOLQJ ZLWK D QXPEHU RI FDVH
VWXGLHV LQYROYLQJ VXUYH\ RU
TXHVWLRQQDLUHV LQWHUYLHZ REVHUYDWRQ
FRPSDUDWLYH VWXGLHV GLDORJXH VHFWRQ
JUDSKLF RUJDQLJHUV FRRSHUDWLYH OHDUQLQJ
HVVDZULWLQJ)DFXOW\RI%XLVQHVV0DQJPHQW
LQJ)DFXOW\RI%XLVQHVV0DQJPHQW
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PRUH FRQWHQWHG ZLWK WKHRULHV DQG
PDWKHPDOLFDQ PRGHOV DQG H[SRVHG ZLWK
YDULRXV ZRUNVRSV DFWLYLWLV ODERUDWRU\
ZRUNH[SHULPHQW)DFXOW\RI%XLVQHVV0DQJPHQW
DQGVLPXODWRQ

:LWK VXFK GLIIHUHQFHV LQ WKH SURJUDP
FXUULFXOXP FRXUVH FRQWHQW DQG WHDFKLQJ
PHWKRRORJ\ LV DVVXPHG WKDW WKH
VWXGHQWV)DFXOW\RI%XLVQHVV0DQJPHQW
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GLIIHUHQW)DFXOW\RI%XLVQHVV0DQJPHQW
WKDW GLIIHUHQW SHRSOH OHDUQ GLIIHUHQW
WKLQJ LQ GLIIHUHQW ZD\ 6RPH VWXGHQWV
XVHG WR SURFHVV H[SHULHQFHV DQG NQRZOHGJH
VHTXHQWLDQ\RWKHU)DFXOW\RI%XLVQHVV0DQJPHQW
PO\VRPHVWXGHQWV
DUHKLJKO\DQDQJ)DFXOW\RI%XLVQHVV0DQJPHQW

RWKHUVXVHWKHLU IHHOLQJV IRU GHFLGLQJ VRPH
VWXGHQWV DUH RULHQWHG YLVXDOO\ RWKHUV
DUHRULHQWHG YHUEDOO\VRPH
VWXGHQWVSUHIHU WR OHDUQ LQ
JURXSVRWKHUVSUHIHUWROHDUQDORQHDQGDWKR
PHHWF>@7KH EURDG GLYHUVLW\ RI WKH VWXGHQW
SRSXODWLRQ LQ WHUP RI DJH H[SHULHQFHV OHYHO
RI SUHSDUHGQHVV FXOWXUH JHQGHU HWF
FUHDWHG YDULRXV OHDUQLQJ VW\OHV DQG
SUHIHUHQFHV DPRQJ WKHP &RQVHTXHQWO\
LQFUHDVH WKH GHPDQGV RQ DFDGHPFLDQV RU
DFDGHPLFERDUGVRUOHDUQLQJSURYLGHUVWRIXOI
LOVWXGHQWV QHHGV
DQGSUHIHUHQFHVWRHQKQDQFHWKHWVWXGHQWV
XQGHUVVDQGLQJOHYHOLQ
WKHOHDUQLQJSURFHVV
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UHSRUWHG>@>@ORVWRIWKHZRUNVDUHIRFXVLQJR
QH[DPLQLQJ WKH OHDUQLQJ VW\OHV EDVHG RQ
YDULRXV IDFWRUV VXFK DV DJH JHQGHU ILHOG RI
VWXG\ DFDGHPLF SHUIRUPDQFH FXOWXUH
WHDFKLQJ PHWKRQ DQG HWF +RZHYHU WKH
ILQGLQJV DUH VWLOO TXHVWLRQDEOH IR VW\OH LV
IRXQG WR EH LQIHULRU WR DQRWKHU ,Q DGGLWLRQ
DV FRQFOXGHG E\ >@ VWXGHQWV DUH QRW
DGDSWLQJ
VLPLODUOHDUQLQJVW\OHVDWDOOWLPHVEHFDXV
HWKH\XVXDOO\FKRRVH WKH VW\OH EDVHG RQ WKH
FRQWH[W RI OHDUQLQJ .D]X >@ QRWHG
WKDWPRVWLQGLYLGXDOVXVXDOO\KDYHRWKHUO
HDUQLQJSUHIHUHQFHV
EHVLGHVWKHLUGRPLQDQWOHDUQLQJSUHIHUHQFH
V+HDOVRFODLPHG
WKDWWKHSUHIHUHQFHVFDQEHFKDQJHG7KXVOHF
WXUHUVDUHKDUGO\ WR DGDSW VXLWDEOH
WHDFKLQJ PHWKRQV WKDW ZLOO VXLW WR HDFK
VWXGHQWOHDUQLQJVW\OHV,QIDFWLQVRPHVWLWXD
WLRQVOHFWXUHUVDUH IRXQG WR DSSO\
WHDFKLQJ PHWKRQV ZKLFK VXLW WR WKHLU RZQ
SUHIHUHQFHV &RQVHTXHQWO\ VWXGHQWV DUH
QRW DEOH WR OHDUQ HHHFWLYHO\
(HHFWLYH OHDUQLQJ LV FORVHO\ DVVRFLDWHG
WR WUDQVIHU RI OHDUQLQJ 7KH JRDO RI WUDQVIHU
RI OHDUQLQJ LV EDVLFDOO\ WR
OHYHUDJHSUHYLXVOHDUQLQJDQGH[SHULHQFH
RPRUHHILFLHQWO\
OHDUQQRVYHOWKDWLVWKHDSSOLFDFWLRQNQRZOH
GJHDQGVNLOOVJDLQHG
LQOHDUQLQJDFWLYLWLHV,QWKLVFRQGLWLRQWKH
DELOLW\ WRWUDQVIHU NQRZOHGJH DQG VNLOOV
JDLQHG IURP SUHYLXV OHDUQLQJ FDQ
SRWHQWLDQO\ EHQHILW D ZLGHUHQJH RI
UHDOZRUG DSSOLFDFWLRQV >@ 7KH WUDQVIHU RI

OHDUQLQJ LV FORVHO\ DVVRFLDWHG ZLWK
OHDUQLQJ SUHIHUHQFHV 6LPRQV >@ KLJKOLJKWHG
WKUHH NLQGV RI
WUDQVIHUURPSULRUNQRZOHGJHWROHDUQIURPOH
DUQLQJWRQHZ OHDUQLQJ DQG IURP OHDUQLQJ WR
DSSOLFDFWLRQ 7KHVH WKUHH
FRQGLWLRQVRIOHDUQLQJDUHVLJQLILFDQWO\UHO
DWHGWLRQVWUXFWLRQDO
VLWXDWLRQVDSSOLHGGXULQJWKHWHDFKLQJDQG
OHDUQLQJSURFHVV
RUGHUWRPD[LPL]HOHDUQLQJDQGWRIDFLOLWDWH
WUDQVIHUURPRQ
VLWXDWLRQOHDUQLQJWRDQRWKHUVLWXDWLRQD
QDSSOLFDFWLRQ

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2QHRIWKHPRVWZHOONQRZQPHWKRQVWGDWVW
SLQDFTXLULQJ LQIRUPDFWLRQ DERXW VWXGHQWV
OHDUQLQJ VW\OHV LV OHDUQLQJ SUHIHUHQFHV
TXHVWLRQDLUH WKDW LV FDOOHG 'XQQ DQG
'XQQ
/HDUQLQJ6W\OH0RGHO'7KH'XQQDQDQ'XQQ/HDUQLQJ6
W\OHV PRGH OOXVWUDWHV D UDQJH RI
VLJQLILFDQW YDULDEOHV WKDW PD\ DIIHFW D
SHUVRQ\V DELOLW\ DQG FRQFHQWUDWLRQ LQ WKH
OHDUQLQJ SURFHVV 6RPH YDULDEOHV DUH
EHOLHYHG WR EH ELRORJLFDOO\
LQIOXHQFHGDQGLQFOLQHWZRZDUGVFKDQJHVDVSH
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7KH HOHPHQWV RI WKH 'XQQ DQG 'XQQ PRGH DUH
JURXSHG DFFRUGLQJ WR ILYH NH\ VWLPXOL >@ >@
FRPSULVLQJ RI
HQYLURQPHQWDOZKHUHZHOHDUQEHVWVFRFLRORJ
LFDQZLWKZKRP ZH FRQFHQWUDWH EHVW
HPRWLRQDOZKDW PRWLYDWHV XV WR OHDUQ DQG
LQIOXHQFHV RXU IHHOLQJV DERXW OHDUQLQJ
SK\VLORJLFDQ ZKHQ DQG KRZ ZH SK\VLFDQO\
HJDJH PRVW LQ OHDUQLQJ DQG SV\FKRORJLFDQKRZ
ZH SURFHVV DQG UHVSROG WR LQIRUPDFWLRQ
DQGLGHV

Environmental Stimuli

,Q WHUPV RI WKH HQYLURQPHQW VWLPXOL WKH
'XQQV QRWHG WKDW
VWXGHQWVGLIIHULQWHUPVRIWKHLUGHILQLWLRQ
VRIDQLGHDOSODFHWWR OHDUQ 6RPH ZDQWHG D
ZDUP EULJKWO\ OLJKW SODFH ZLWK GHVNV PDQ\
SHRSOH DURXQG DQG LQYROYH PFXK YHUEDO
LQWHUDFWLRQ
ZKLOHWRWKHUVDUHSUHIHUHQHGFRRORJUHVVXEG
XHGOLJKWLQJZLWK D TXLWHU DQG PRUH
LQIRUPDO HQYLURQPHQW 7KRXJK PDQ\
OHFWXUHUV EHOLHYH WKDW WKH\ KDYH OLWWHO
FRQWURO RYHU WKHVH HOHPHQWV 'XQQ DQG 'XQQ
GHVFWLEH KRZ WKH VWDQGDUG VTXDUH

ER[RIDFODVVURRPFQEHSDUWLWLRQHGLQWRVHS
DUDWHDUHDVZLWK GLIIHUHQW HQYLURQPHQWDO
FOLPDWHV 7KXV E\ NQRZLQJ WKH OHDUQLQJ
VW\OHV RI VWXGHQWV OHFWXUHUV FDQ RUJDQLJH
WKH
FODVVURRPPVHWWLQJLQUHVSROGLQJRWKHLUVW
XGHQWV¶QHGGVHLWKHU IRU D TXLHW SODFH
EULJKW RU VRIW LOOXPLQDWLRQ ZDUP RU FRRO
URRP WHPSHUDWXUHV GLIIHUHQW W\SHV RI
VHDWLQJ DUUDQJHPHQW
PRELOLWRUJURXSSUHIHUHQFH>@

7KHLPSRUWDQFHRIHQYLURQPHQWDOVSHFWVL
VDOVRKJLJKOLJKWHG E\ >@ LQ FRQGXFWLQJ D
SDWLHQW HGXFDFWRQ WR VWUHV XULQDU\
LQFRQWLQHQFH68, SDWLHQWV 7KLV W\SH RI
OHDUQHUV LV PRUH VHQVLWLYH WR GLVFRPIRUW
7KXV WKH SK\VLFD VHWLQJ URRP
WHPSHUDWXUHOLJKWLQJQDQGLVHOHYHOVKRXO
GEHDVFRPIRUWDEOH DV SRVLEOH,Q RWKHU ZRUN
>@ KDV FRQFOXGHG WKDW VHDWLQJ
DUUDQJHPHQW LQ D FODVVURRPP GLUHFWDU\
DIIHFVW WKH IORZ RI LQWHUDFWLRQV EHWZHHQ
IDFLOLWDFRQW DQG VWXGHQWV WKH TXDOLW\ RI
OHDUQLQJQDQGWXVUHTXLUHVIUWKHUHVHDUF
KJURPKLVSHUVRQDO H[SHULHQFHV KH ZDV
VXJHVVWLQJ D XVKDSHG VHDWLQJ ZKLFK LV PRUH
SURSHU IRU DXWKHQWLF GLVFXVLRQV DQG DEOH
WR LQFUHDVH
VWXGHQWV¶HQJDJHPHQWGXULQJFODVVHV

Emotional Stimuli

7KHHPRWLRQDOVWLPXOLFHQWHURQWKHH[WHQ
WWRZKLFKVWXGHQWV DUH VHOIGLUHFHWG
OHDUQHUV \$W RQH HQG RI WKH FRQWLQXXP DUH
VHOIVWDUWHUV ZKR FDQ EH JLYHQ D ORQJ WHUP
SURMHFW DQG ZKR
PRQLWRU DQG SDFH WKHPVHOYHV XQWLO
ILQLVKLQJ WKH MRE \$W WKH RWKHU HQG DUH
VWXGHQWV ZKR QHHG FRQVLGHUDEOH VXSSRUW
DQG
SUHIHUWRKDYHWKHLUDVVLJQPHQWVLPDOOFK
XQNVZLWKSHULRGLF GXH GDWHV 6PHVWHUORQJ
SURMHFWV ZLWKRXW SHULRGLF FKHFNV ZRXOG EH
GLVDVWURXV IRU WKHVH VWXGHQWV
8QGHUWDQGLQJ WKH VWXGHQWV¶ DSSDUHQW
QHGGV IRU OHDUQLQJ VXSSRUW DOORZV WKH
OHFWXUHUV WR GHVLJQ OHDUQLQJ H[SHULHQFHV
WKDW KHOS VWXGHQWV
VXFFHHGDQGOHDUQPRUHHIHFWLYHO\
3DVW UHVHDUFKKDV FRQVLVWHQWU\
UHSRUWHG SRVLWLYH DQGUREXVW
FRUOHODWLRQV EHWZHHQ WKH VWXGHQWV¶
PRWLYDWRQDO OHYHO DQG KLV RU KHU DFDGHPLF
DFKLHYHPHQW >@ (VSRVLWR >@ VWDWHG WKDW
VWXGHQWV¶ ZKR FUHGLW WKHPVHOYHV IRU
VXFFHVW WHQG WR KDYH D KLJKHU
PRWLYDWRQDO OHYHO DQG SHUVLVW ORQJHU DW

WDVN DV WKH\ EHOHYH WKH\ FRQWURO RYHU
WKHLU VXFFHVW RU IDLOXUH 6PLODUO\ >@
FRQFOXGHG WKDW PRWLYDWHG SDUWLFLSDQW
OHDUQ PRUH DQG SHUIRUP EHWWHU WKDQ
XQPRWLYDWHG SDUWLFLSDQWV ,Q RWKHU ZRUN
>@LQGLFDWHGWKDWVWXGHQWVQHGGWREHHQFR
XUDJHGWKURXJKRXW
WKH OHDUQLQJ SURFHVV VR WKDW WKH\ FDQ
EHFRPH PRUH VHOI

6WXGHQWV DUH DOVR GLIIHUHG LQ KRZ WKH\
UHDFW WR SHHU
LQWHUDFWLRQV6RPHGLVOLNHJURXSSURMHFWVSU
HIHUULQJLQVWHDGWR
OHDUQE\WKHPVHOYHVVRWKHUVWKULYHRQWKHFRP
SDQLRQVKLSDQG
VXSSRUWSURYLGHGE\JURXSZRUN6WLOORWKHUVS
UHIHUWKHPRUH WUDGLWLRQDO DSSURDFK RI
OHDUQLQJ IURP DQ DGXOW 7KHVH SUHIHUHQFHV
FDQ EH VDWLVLHG E\ YDU\LQJ WHDFKLQJ
WHFKQLTXHV
EDVHGRQGLIIHUHQWOHDUQLQJFRQILJXUDWLRQV
7KHVXFFHVVIXORI JURXS ZRUN KDYH EHHQ
ZHOO
66VWXGHQWVIDYRURIZRUNLQJDORQH

Physiological Stimuli

\$QRWKHU LPSRUWDQW VWLPXOXV LGHQWLILHG
E\ WKH 'XQQV >@ LV UHODWHG WR LQGLYLGXDO
GLIIHUHQFHV LQ WHUPV RI SK\VLROJLFD
SUHIHUHQFHV 3UREDEO\ WKH PRVW LPSRUWDQW
HOHPHQW KHUH LV OHDUQLQJ SHUFHSHWXDO 0DQ\
VWXGLHV RI SHUFHSHWXDO SUHIHUHQFHV KDGEHHQ
FRQGXFWHG LQ WKHILHOGRI KLJKHU OHDUQLQJ
HGXFDFWRQ
LQYROYLQJ66VWXGHQWV8JXQHWDO>@FRQGXFWH
GDVXUYH\WR GHWHUPLQH OHDUQLQJ VW\OHV RI
VWXGHQWV LQ WKH)DFXOW\ RI (GXDFWRQ
DW80XGDJ8QLYHUVLW\ ZKLFK LQYROYHG
WHQGLIIHUHQW GHSDUWPHQWV 7KH UHVXOW
VKRZHG WKDW PRVW RI WKH VWXGHQWV LQ
DOOGHSDUWPHQWVZHUHPRUHYLVXDODWKHUWK
DQDXGLWRU\,QRWKHU
ZRUN>@FDUULHGRXWDVXUYH\WRYDOLGDWHWKH
OHDUQLQJW\OHVRI VWXGHQWV HQUROOHG LQ
WKH FRXUVH RI (FRQRPLFV DQG VLPLODU UHVXOWV
ZHUH UHSRUWHG 7DEDWDEDHL DQG 0DVKD\HNKL
>@
FRQGXFWHGWKH3URGXFWLYLW\ (QYLURQPHQWDO
3UHIHUHQFH6XUYH\
3(36E\XQQDQGXQQ\HQUQLQJ6W\OH0RGHWRH[DPL
QH
WKH VLJQLILFDQW GLIIHUHQFHV LQ OHDUQLQJ
VW\OHV RI ,UDQLDQ SUH
XQLYHUVLW\ (QJOLVK)RUHLJQ /DQJXDJH(/
OHDUQHUV DFURVV
GLIIHUHQWVHOHYHOVRISURILFLHQF\PDMRUVDQJHQ

GHUV7KHUHVXOWV VKRZHG WKDW
SDUWFLSDQWV SUHIHUUHG YLVXDO VW\OH WKH
PRVW IROORZHG E\ DXGLWRU\ WDFWLOH DQG WKH
OHDVW SUHIHUUHG OHDUQLQJ VW\OH ZDV
NLQHVWVKHWLF 7KRXJK WKH WHQGHQFLHV ZHUH
GLIIHUHQW EXW WKH DFDGHP LFDFKLHYHPHQWV RI
WKHVH VWXGHQWV VKRZHG QR VLJQLILFDQW
GLIIHUHQFHV ,W KDV DOVR REVHUYHG WKDW
ILHOG RI VWXGLHV DQG JHQGHU KDYH QR HIIHFV
RQ WKH OHDUQLQJ VW\OH SUHIHUHQFHV 6LPLODU
ZRUN ZDV FRQGXFWHG E\ %LGDEDGL DQG <DPDW >@
RQ () VWXGHQWV 7KH ILQGLQJ V KRZ WKDW WKH
PDMRULW\ RI WKH VWXGHQWV FRQVLGHUH
WKHPVHOYHV DV FRPPXQLFDWLYH OHDUQHUV
2WKHU ZRUN GRQH E\ 0HKUGDG DQG
\$KJKDU>@DOVRFQFOXGHVWKDW()/VWXGHQWVD
W,VODPLF\$JG
8QLYHUVLW\DUHDXGLWRU\DQGYLVXDOOHDUQHU,
QFRQWUDVW7XOEYUH
>@KDVFRQGXFWHGDFRPSDULVRQVWXG\EHWZHHQ
WZRJRXSURI SUHVHUYLFH WHDFKHUV LQ WKH
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ILHOGV LQ RUGHU WR LGHQWLI\ WKHLU OHDUQLQJ
VW\OHSUHIHUHQFHV DQDFDGHPLF SHUIRUPDQFH,
WLVRQWHG WKDW
WKH(GXFDFWRQDO6FLHQFHV VWXGHQWVZLWKSUH
GRPLQDQWFRQYHUJHU
OHDUQLQJ VW\OHVHPWRDFKLHYHKLJKHUHVXO
VWVKDQWKHVWXGHQWV LQ WKH (FRQRPLF
6FLHQFHV ZKHUH WKH GLYHUJHU VWUDWHJ\ EHLQJ
DSSOLHG 7KH FRQYHUJHU SUHIHUV WR EH JXLGHG
WKURXJK DQ H[SHULPHQW UDWKHU WKDQ
UHFHLYLQJ RUDO LQVWUXFWLRQ DEVWUDFW
FRQFHSWXDOL]DWLRQ DQG DFWLYH
H[SHULPHQWDWLRQ ZKHUHDV GLYHUJHU LV
LQYROYHG FRQFUHWH H[SHULPHQWDWLRQ DQG
UHIOHFWLYH
REVHUYDWLRQ2QWKHRWKHUKDQGDQXPEHURIZRU
NVUHSRUWLQJ RQ OHDUQLQJ SUHIHUHQFHV
DPRQJVW 6 7 VWXGHQWV LQ WHUPV RI
LQYHVWLJDWHG WKH OHDUQLQJ VW\OH
SUHIHUHQFHV DPRQJVW XQGHUJUDGXDWL DQG
JUDGXDWL RI WKHUDS\ VWXGHQWV LQ 7DLZDQ
ZKLFLVUHODWHGWRDFDGHPLF SHUIRUPDQFH7KHI
LQGLQJVKRZ WKH PRVW FRPPRQ\ RFFXUULQJ
VW\OH RI WKH OHDUQHUV ZDV DVVLPLODWRU
IROORZHG E\ GLYHUJHU DFRPPRQDWRU DQG
FRQYHUJHU IR VLJQLILFDQW GLIIHUHQFH LQ WKH
DFDGHPLF SHUIRUPDQFH DPRQJ WKH IRXU
GLIIHUHQWVW\OHVRIOHDUQHUV,WZDVDOVRIRXQG
WKDWDVVLPLODWRU OHDUQHUV SUHIHU
DEVWUDFW FRQFHSWXDOL]DWLRQ DQG
UHIOHFWLYH REVHUYDWLRQ
SK\VLORJ\ VWXGHQWV
6LOYHUPDQ WR PHDVXUH RSWRPHWU\ VWXGHQWV
DQG IRXQG WKDW WKH

PDMRULW\RIWKHPKDYHEDODQFHODUQLQJ VW\OH
V

3HUFHSDXDO LQWLNH WLPH DQG PRELQW\ DUH
DVSHFWV LQ WKH SK\VLORJLFDO VWLPXOL 6RPH
VWXGHQWV PD\ UHTXLUH VQDFNV RU OLJKW
UHIHUVKPHQW WR NHHS WKHLU OHDUQLQJ
PRPHQWXP ,Q WLPH
DVSHFWVPRPHRIWKHPDUHPRUQLQJSHRSHZKLOHR
WKHUVGRQRW IXQFWLRQ IXOO\ XQWLO ODWHU LQ
WKH GD\ \$V IRU WKH PRELQW\
WHDFKHUVRUOHFWXUHVDUHDEOHWRDFRPPRQD
WHWKHVH VWLPXOLE\ VHWWLQJ XS OHDUQLQJ
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EHRQHRIWKH
FKDOOHQJHVIRUWHDFKHUVRUOHFWXUHUVWRDFR
RPPRQDWH *Psychological Stimuli*

7KH ILIWK DQG ILQDO OHDUQLQJ VW\OH VWLPXOL
LV SV\FKRORJLFDO
7KLV VWLPXOXV UHIHUV WR WKH JHQHUDO VWUDWHJ
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DW WKH ELJ SLFWXUH ZKLOH RWKHUV
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UHODWHG WR EUDLQ KHPLVSKHUH VXJJHVW
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JUDPPDWLFDQ VWUXFWXUH DQG FRQWUDVWLYH
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VTXLFNQ\XQOLNH WKH UHIOHFWLYH RQH V ZKR
WKLQN DERXW YDULRXV DOWHUQDWLYHV DQG
OHFWXUHUVZLOODFHGLIIHUHQW OHDUQLQJ VW\OH
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EHRPH PRUH VHQLWLYH WR WKH GLIIHUHQFHV
DQG PDNH D QHFHVVDU\ DGMXVPHQW WR
DFRPPRQDWH WKH
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7KH RWKHU FULWLFDO GLOHPPD LV KRZ WR
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NQRZOHGJHDQGNLOOVWRQHZOHDUQLQJVLWXDW
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IDFLOLWDWH OHDUQLQJ LV FUXFLDO >@ 0RUHRYHU
RUJDQL]DWLRQV V KRXOG FRQVLGHU WUDQVIHU RI

DXWKRULW\ RU UHFRJQLJHG VSHFLDO NQRZOHGJH
LV SUHVHQW ZKLFK IDOOV XQGHU WKH
VRFLRORJLFDO SUHIHUHQFHV 3K\VLRORJLFDO
FKDUDFWHULVWLFV FRYHU OHDUQHUV¶
SHUFHSWXDO VWUHQJWKVDXGLWRU\ YLVXDO
WDFWLOH RU NLQHVWKHWLF PRGDOLW\ WLPHRIGD\
SUHIHUHQFHV WR OHDUQ EHWWHU HLWKHU
PRUQLQJ DIWHUQRRQ RU
HYHQLQJLQWLNHUHTXLUHPHQWVVDNFNLQJRUVLS
SLQJGXULQJWKH SURFHVV RI OHDUQLQJ RU
PRELOLW\ YHUVXV SDVVLYLW\ QHHGVVWD\
SXWRUPRYLQJDURXQGZKLOHHQJDJHGLQOHDUQLQJ
/DVWEXWQRW OHDVW LV WKH SURFHVVVLQJ VW\OH
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VRUJDPHV

95(68/76\$1",6&866,21 Environmental Stimuli

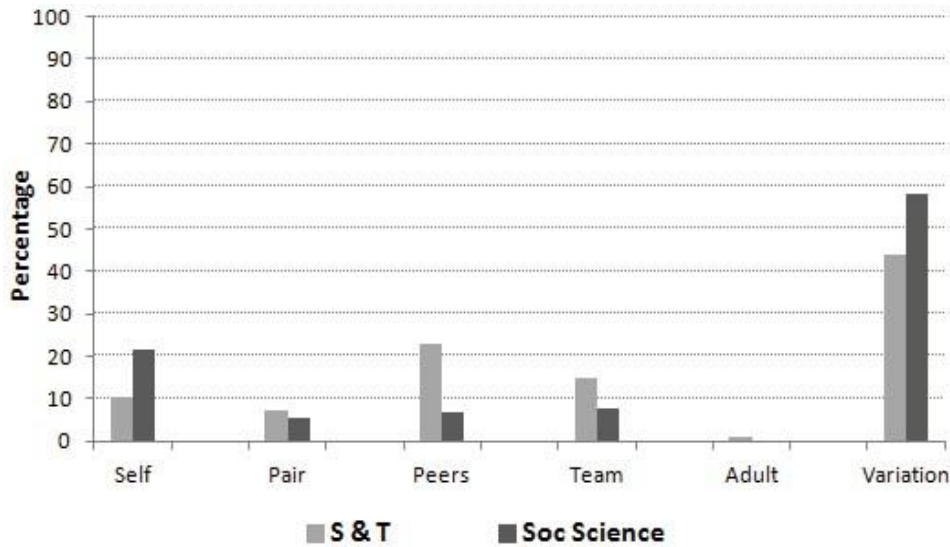
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)RU OLJKWLQJ HOHPHQW 6 7 VWXGHQWV DUH
VWLOO LQ D EDODQFHG GLVWULEXWLRQ EHWZHHQ
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LPSRUWDQWIRUROGHUVVWXGHQWVZKRPD\FKLOOPR
UHHDVLO\,WKH
VWXGHQWVVKDYHKKHDULQJRUYLVLRLQPSDLUPHQW
VWKLVDQLPSDFW RQ WKH HGXFDWLRQDO
SURFHVV DQG SRVVLEO\ PDNH WKH VWXGHQWV
DSSHDULQVHFXUHRUXQDEOHWRFRPSUHKHQGWKH
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6 7 DQG 66 VWXGHQWV DUHGLVWULEXWGH
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LQIRUPDO VHDWLQJ GHVLJQ ,Q PRVW RI KLJKHU
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QRUPDOO\ IRUPDOO\ DUUDQJHG :LWK VXFK
ILQGLQJV UHFRQVWUXFWLRQ RI WKH FODVVURRP
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Emotional Stimuli
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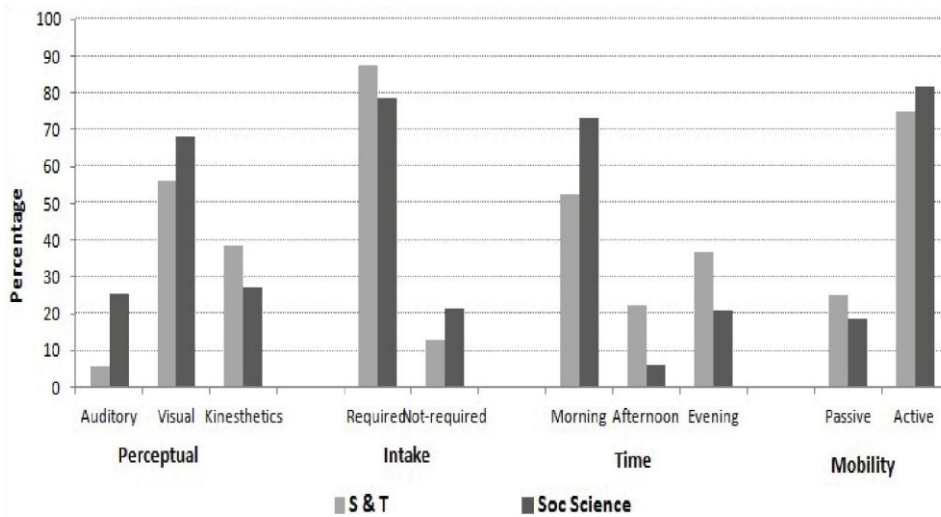
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RG

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VKRZV SRVLWLYH
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FOXVWHUVDUH
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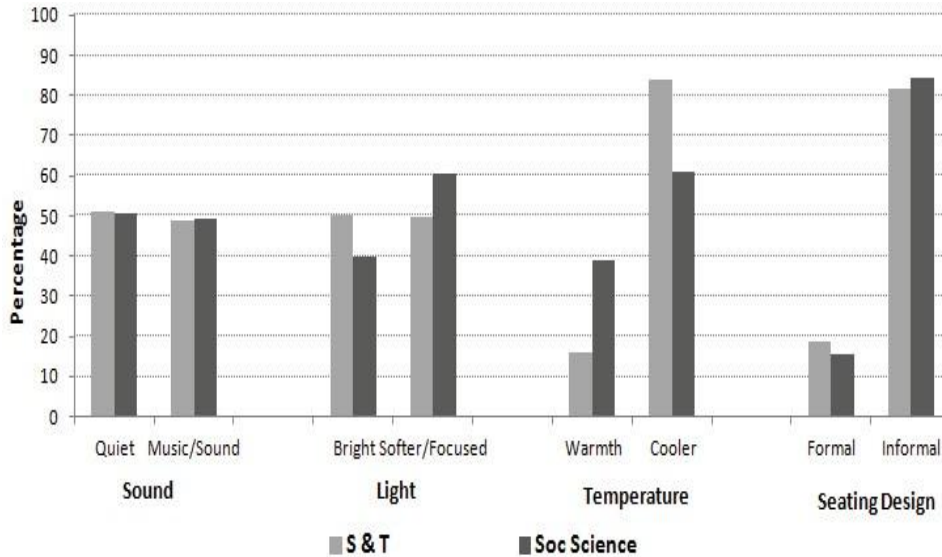
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)LJ6RFLRORJLFDQ(OHPHQWVGLVWULEXWLRQ



)LJ3K\VLORORJLFDQ(OHPHQWVGLVWULEXWLRQ



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Physiological Elements

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)RUWKHLQWDNHHOHPHQWVUHVJDUHGOHVVRIJURX SRIVWXGHQWVWLWLV REYLRXVO\SURYHQWQWVWKHVWXGHQWVSUHIHU WREHLQDUHOD[LQJ DQGHQMR\LQJPRGHZLWKVRPHOLJKWRIUHIUHVKPH QWV7KXVE\ DOORZLQJ WKH FRQVXPSWLRQ RI OLJKW VQDFNV HVSHFLDOO\ LQ WKH HDUO\PRUQLQJVRORWVKRXOGEHFRQVLGHUHG2QWK HWLPHDVSHFW PRUQLQJQGHYHQLQJSHULRGVDUHVHHQWREHPRU HIDYRUDEOHE\

)RU JOREDODQDO\WLFDO DVSHFW DQG KHPLVSKHULFD0 HOHPHQWV FRQWUDGLFWRU\UHVXOWVDUHVHHQEHWZHHQ6 7DQG66VWXGHQWVVDV LOOXVWUDWHGLQJLJ0DMRULW\RI6 7VWXGHQWVVLVIRXQGWREH PRUHDQDO\WLFDOOHDUQHUVZKHUHDVWKHPDMRU LW\RI66VWXGHQWVVLV JORED0 OHDUQHUV 7KH ILQGLQJ LV FRQVLVWHQW ZLWK FXUUHQW FXUULFXOXPVUDFWLWFHVKHUH6 7FXUULFXOXPVXDDO\EHJLQZLWK WKHRU\ DQG WKH FRQFHSW EHIRUH H[WHQGHG WR UHDO DSSOLFDWLRQ :KLOH66FXUULFXOXPVUDHGHYHORSHGEDVHGRQD QLQWURGXFWRQ RI WKHRUHWLFD0 SHUVSHFWLYHV DQG EURDGHQ LQWR DSSOLFDWLRQV E\ SURYLGQJ H[DPSOHV RI DSSOLFDWLRQ FDVHV 7KH WHDFKLQJ VWUDWHJLHV DUH DVVRFLDWHG ZLWK FDVH VWXGLHV UROH

SODV EHKDYLRUDO PRGHOLQJ GLVFXVVLQRV DQG
SUHVHQWDLRQ LGHD
JHQHUDLRLQIRUSUREOHPVROYLQJIDXOWILQGLQJ
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QRWLFHG WR EH OHW
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DFFXUDF\KLOVW ULJKW EUDLQGRPLQDQW ZRXOG
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IHHOLQJ DQGFUHDWLYLW\
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7KHUHVXOWVIURPWKLVVWXG\GHVFULEHOHDUQ LQSUHIHUHQFHVRI XQGHUJUDGXDWLV IURP WKH OHFKDQLFDO (QJLQHHULQJ DQG %XVLQHV 0DQDJPHQW RI 8L70 3XODX 3LQDQJ %DVHG RQ WKH ILQGLQJV WKH UHVHDFKHUV ILQDOO\ GLVFORVHG WKH SUHIHUHQFH OHDUQLQJ VW\OHV RU SUHIHUHQFHV DPRQJVW 6 7 VWXGHQWV DQG 66 VWXGHQWV7KHUHVXOWVUHYHDOHGKDWERWKJ URXSVRIVWXGHQWVVDUH H[KLELWLQJ VLPLODU OHDUQLQJ SUHIHUHQFHV)URP HOHPHQWV OLVWHG LQ 'XQQ DQG 'XQQ /HDUQLQJ 6W\OH TXHVWLRQQDLUH RQO\ WZR HOHPHQWV GUDZQ ZLWK GLIIHUHQW FRQFOXVLRQV 0DMRULW\ RI 6 7VWXGHQWVLRXQGWREHPRUHDQDO\WLFDOOHD UQHUVZKHUHDV WKHPDMRULW\RI66VWXGHQWVVDUHJOREDOOHDUQ HUV,WLVDOVRQRWHG WKDW 6 7 DQG 66 VWXGHQWV DUH DOVR GLIIHUHQW LQ KHPLVSKHULFDO HOHPHQW7KH6 7VWXGHQWVVDUHSURYHQDVOHIWEUDLQGRPLQDQ W DQG66VWXGHQWVVDUHULJKWEUDLQGRPLQDQW)RUI LQDOHOHPHQWLQ SV\FKRORJLFDQ VWLPLXOL LH LPSXOVHUHIOHFWLYH WKH PDMRULW\ RI VWXGHQWV IURP ERWK 6 7 DQG 66 H[KLELW UHIOHFWLYH FKDUDFWHULVWLF ZKLFK LQGLFDWH WKDW WKH\ DUH YHU\ GHWDLOHG DQG SDUWLFXODUV LQGLYLGXDO 7KH\ ZRXOG WKLQN DERXW YDULRXV DOWHUQDWLYHV DQG HYDOXDWH HDFK DOWHUQDWLYH EHIRUH PDNLQJ D GHFLVLRQ\$VDFRQFOXVLRQLWFDQEHGUDZQWKDW6

7DQG66 VWXGHQWV DUH KDYLQJ VLPLODU OHDUQLQJ SUHIHUHQFHV H[FHSW RQ SV\FKRORJLFDOSUHIHUHQFHV 7KH UHVXOW JDLQHG LQ WKLV ZRUN LV DOVR QRW FRQVLVWHQW ZLWK SUHYLRXV ZRUNV WKDW KDYH EHHQ UHSRUWHG 7KLV SRLQWHG WKDW OHDUQLQJ SUHIHUHQFHV DUH ZLGHQ\ GLYHUVH DPRQJ VWXGHQWV RU OHDUQHUVDURXQGWKHZRUOG6VWXGHQWVZLWKVLPLODUDJHJHGHU ILHOG RI VWXGLHV DQG FXOWXUH PD\ H[KLELW GLIIHUHQW OHDUQLQJ VW\OHVDWGLIIHUHQWSODFHRUGLIIHUHQWXQLYH UVLW\7KLVLQGLFDWHG WKDW PDQ\ RWKHU XQIRUHVHHQ IDFWRUV PD\ DIIHFW WKH VWXGHQWV¶ OHDUQLQJ SUHIHUHQFHV 7KH ILQDO VROXWLRQ LQ XQGHUVDQGLQJ VWXGHQWV OHDUQLQJ SUHIHUHQFHV UHPDLQV XQNQRZQ 7KXV OHFWXUHUV DUH VWURQJO\ VXJJHVWHG WR ILUVW GHWHUPLQH WKHLU VWXGHQWV¶ OHDUQLQJ SUHIHUHQFHV HYHU\ WLPH WKH QHZ FODVVHV VWDUWHG *HWWLQJ WR XQGHUVDQGLQJ WKH VWXGHQWV OHDUQLQJ SUHIHUHQFHV LQFOXGLQJ WKHLU SHUVRQDOLW\ DELOLW\ DQG LQWHOOJHGHZLOOFUHDWHDFORVHUHODWLRQV KLSEHWZHHQOHFWXUHUV DQG VWXGHQWV WKXV ERRVW XS VWXGHQW HQJDJPHQW DQG PRWLYDWRQ 7KHVH ILQGLQJV ZLOO DOVR EHQHILW WKH OHFWXUHUV LQ GHVLJQLQJ OHDUQLQJ VWUDWHJLHV HIIHFWLYHO\ HVSHFLDOO\ WR WKRVH OHFWXUHUV ZKR WDXJKW FRPSXOVRU\ XQLYHUVLW\ VXEEMHFV FRXUVHV ZKLFKLQYROYHGERWK6 7DQG66VWXGHQWV/HFWXUHUVVDUHDQVR HQFRXUDJHGWRDQDFHWKHYDULHW\RIOHDUQLQJ SUHIHUHQFHVDQG VW\OHV WR HQFRXQWHU WKH OHDUQLQJ SUHIHUHQFHV IRU PLQRULW\ JURXS ,Q RWKHU ZRUGV D μRQH VL]H ILVW DOO¶ DSSURDFK LV QR ORQJHU SUDFWLFDO LQ WKH FXUUHQW HGXFDRWRQDO HQYLURQPHQW +HQFH WKH XQLYHUVLW\ DFDGHPLFV VKRXOG EH HTXLSSHG ZLWK WHDFKLQJ VNLOOV RU WHFKQLTXHV DGHTXDWHO\ SUHSDUHG IRU WKH WHDFKLQJDOOWKHGLVFLSOLQHVZKLFKDUHDOLQJ HGZLWKDSSURSULDWH SKLORVRSKLHV DQG PHWKRRORJLHV RI WHDFKLQJ 6XFK DELOLWLHV DQG H[HUFLVHV FDQ RQO\ EH GHYHORSHG WKURXJK GHOLEHUDWH WUDLQLQJ SURJUDPV ZKHU WKHLU WHDFKLQJ FRPSHWQFLHV VKRXOG EHVHVVHG DQGFHUWLVLHG WREHGHHPHGSURIHVV LRQDOV7KLVZRXOG HQVXUHWKHHIIHFWLYHQHVVRWKHWDFKLQJDQG OHDUQLQJDFWLYLWLHV ,WLVDOVREHQHILWHGDQGHOSHGHDFKHUVRUO HFWXUHUVWRSODQDQ FUHDWH IULHQGO\ DQG FRQGXFLYH WHDFKLQJ DQG OHDUQLQJ HQYLURQPHQWV WKDW ZLOO HQKDQFH WKH

VWXGHQWV OHDUQLQJ LQWHUHVWV
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)XUWKHUVWXGLHVPD\DOVREHGLUHFVHGLQFRQI
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DSSO\LQWKHLUOHDUQLQJ\|VIRFXVLQJLQWRGLIHU
HQWILHOGVRIVWXG\ DQG DOVR WR H[DPLQH
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ILQGLQJZLWOOEHDEOH WR LQFUHDVH
OHFWXUHV\ DZDUHQHV RQ KRZ WR GHYHORS
FRPSUHKHQVLEOH OHVVRQV PRUH HIIHFWLYHO\
DQG FDSWLYDWH WKHLU WHDFKLQJ VWUDWHJLHV
VXFFHVIXOO\ ,W ZRXOG DOVR FRQWULEXWH WR
FRQGXFLYH OHDUQHUIULHQGO\ HQYLURQPHQWV
DQG WKXV PD[LPL]H WKHWUDQVIHURIOHDUQLQJ\|V

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6\|ULD3URFHGLD6RFLDODQG%HKDYLRUDO6FLHQFHVSS±
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6ORYHQLDSQH[SHULHQWLDODQG\|GK\|HRULV\|WLFDOFDVH,QWH
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*)UHQFK 7 &RVJULII DQG 7 %URZQ /HDUQLQJ VW\OH
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\$XVWUDOLDQ RFXSDWLRQDO WKHUDS\ VWXGHQWV
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:DQJ3-/HH:6+X0+:X<7/HDUQLQJ\|VW\OHVRI XQGHUJUDGXDWH
DQG JUDGXDWH SK\|VLFDO WKHUDS\ VWXGHQWV LQ 7DLZDQ
3URFHGLD 6RFLDO DQG %HKDYLRUDO 6FLHQFHV SJ ± GRL
MVEVSUR
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DFDKLHYHPHQW LQ KLJKHU HGXFDFWLRQ \$ FURVVHFWLRQDO
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3URFHGLD 6RFLDO DQG %HKDYLRUDO 6FLHQFHV SS
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OHDUQLQJ\|VW\OHV\|HQUROPHQWV\|WDXV\|DQJGHQGHURQDFD
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SUDFWLFH UHJLVWUDUV *British Journal of General Practice.*
SS±

**6DOLQD%XLQ,U'ULVFXUUHQWO\|D6HQLRU/HFWXUHUDW)DF
XOW\|RI0HFKDQLFDO (QJLQHHULQJ 8QLYHU\|VWLW 7HNQRORJL
0DUD &DZDQDQ 3XODX 3LQDQJ 6KH
FRPSOHWHGKHUXQGHUJUDGXDWHV\|VWXGLHVLQ0DWHULDO(Q
JLQHHULQJ+RQVLQ
DW8QLYHU\|VWLW6DLQV0DOD\|VLD\|HDUVODWHU\|VVKHFRQWLQX
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XQLYHU\|VW\ DQG JUDGXDWHG ZLWK 06F0HFKDQLFDO
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IXUWKHULPSURYH\|KHUVNL0OLQHGXFDFWLRQV\|KH\|D\|VXQGHU
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%HIRUH\|DSSRLQ\|WHDV\|D\|OHFWXUH\|UDW8L70ODVW\|H\|DUV\|D
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WKURXJKZRUNLQJH[SHULHQFHV\|LQWKUHH\|PDQ\|IDFWXULQJL
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URGX\|F\|W\|X\|D\|OL\|S\|URG\|X\|F\|U\|H\|OL\|D\|OL\|W\|F\|X\|V\|R\|P\|H\|U
UH\|W\|X\|U\|X\|D\|OL\|W\|P\|R\|L\|W\|R\|L\|Q\|J\|V\|V\|W\|H\|P\|/H\|D\|Q\|P\|D\|Q\|J\|H\|P\|H\|Q\|W
V\|V\|W\|H\|P\|D\|Q\|G\|V\|X\|S\|S\|O\|F\|K\|D\|L\|Q\|P\|D\|Q\|J\|H\|P\|H\|Q\|W
&XUUHQWO\|VKH LV D &RUSRUDWH 0HPEHU RI ,QVWLWXWH
RI (QJLQHHULQJ 0DOD\|VLD DQG 3URIHV\|VLRQDO (QJLQHHU
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LQWHUHVW UHVHDFK ILHOGV LQFOXGLQJ DGYDQFHG
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**6KDLUD,VPDLOLV\|D6HQLRU/HFWXUHUDW\|W\|KH)DFXOW\|RI%XV
LQHV\|V0DQD\|J\|H\|P\|H\|Q\|W 8QLYHU\|VWLW 7HNQRORJL 0DUD 3XODX
3LQDQJ 6KH KDV \H\|DUV RI ZRUNLQJ
H[SHULHQFH\|D\|V\|W\|KH+5SUDFWL\|WLRQ\|HULQ\|W\|KH\|FRQ\|J\|OR\|P\|H\|D\|W
HFRPSDQ\|LQ0DOD\|VLD
+H\|DU\|H\|D\|V\|RIH[SHU\|W\|V\|H\|DU\|H\|RQ\|G\|X\|V\|W\|L\|D\|O\|5\|H\|O\|D\|WLRQV&R
OOHFWLYH%DUJDLQLQJ\|DQ 7UDGH 8QLRQ (PSOR\|PHQW \$FW
DQG /DERU /DZ 3HUIRUPDQFH 0DQD\|J\|H\|P\|H\|Q\|W
6\|V\|W\|H\|P\|*UL\|H\|D\|Q\|F\|H\|3URFH\|G\|X\|U\|H\|(PSOR\|H\|5\|H\|O\|D\|WLRQV+506WU
D\|W\|H\|L\|F\|3\|O\|D\|Q\|L\|Q\|J\| 2UJ\|D\|Q\|J\|D\|WLRQDO 'YHORS\|P\|H\|Q\|W DQG
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:RUN6\|V\|W\|H\|P\|V+3:6V7UDLQLQJ\|H\|H\|G\|V\|V\|H\|V\|P\|H\|Q\|W\|DQ\|G\|D\|Q\|W
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