

,QYHVWLJDWLRQ RI YDOLGLW\ DQG
SRVWJUDGXDWLW PDWKHPDWLFV W
TXDOLWDWLYH UHVHDFK LQ 7XU
GDWD FROOHFWLRQ WRRO

g]NDQ (UJHQLQ =HODDQGD\$O'LO' HOLFH
6DNDU\D 8QLYHUVLW\)DFXOW\ RI (GXFDWLRQ +HQGH
0DUPDUD 8QLYHUVLW\ \$WDWXUN)DFXOW\ RI (GXFDWLRQ ,VW

\$EVDUQFWKLV UHVHDFK PDVWHU DQG GRFWRUDWH
TXDOLWDWLYH PHWKRQ LQ PDWKHPDWLFV HGXFDFWLF
WKRURXJKO\ LQVSHFWHG LQ WHUPV RI WKHLU YDOLG
UHVHDFK KDV D FDVH VWXG\ DV D UHVHDFK PRGH
&RXQFLO RI +LJKHU (GXFDWLRQ PDVWHU WKHVLV
FRQWDLQV ERWK SULPDU\ DQG VHFRQGDU\ PDWKHP
GRFWRUDWH WKHVLV DUH DQDO\VHG E\ XVLQJ GRFXP
GDWD LV UHVROYHG E\ PHDQV RI FRQWHQW DQDO\VLV
WKDQ KDOI RI WKHVH WKHVHV LQ ZKLFK UHOLDELWLW
DGGLWLRQ WR WKH FUHGLELWLW\ WUDQVPLVVLELWLW
VWUDWHJLHV WKDW LV XVHG IRU TXDOLWDWLYH SDUD
DOVR XVHG LQ UHJDUGV RI TXDQWLWDWLYH SDUDGLJ
GHYHORSPHQW DQG DGDSWDWLRQ ZRUNV ODQJXDJH
XVHG DQG LQ DOPRVW KDOI RI WKHP LW ZDV REVHUYH
ZRUNV ZHUH QRW HPSOR\HG ,Q WKLV FDVH LW VKR
&UHGLELWLW\ ZRUNV UHPDLQV XQIXOILOHG DQG DZD
WKDW DUH FDXVHG E\ VFDOH GLIIHUHQFHV UHPDLQV O

,QWURGXFWRQ

,W LV UHTXLUHG WKDW UHVXOWV DQG YHULVLPLWLW
SDWK WR QHZ PRYHPHQWV LQ WLPHV RI SDUDGLJP FKD
V\ VWHPDWLF GDWD JDWKHULQJ SURFHVV LQ DQ HQYLUR
NQRZOHGJH ,Q FRQWHPDOWLRQ RI WKH IDFW WKDW LW
LV DQ DFFHSWDEOH IDFW WKDW HYHU\ VLQJOH VFLHQW
HUURU *HQHUDOO\ HUURU LV GHVFULEHG DV WKH GI

^D &RUUHVSRQGLQJ DXWKRU R]NDQHUIJHQH#VDNDU\D HGX

PHDVXUHG YDOXH DQG LW VKRXOG DOVR EH DGGUHVVH
SHULRG HUURU FDQ EH RULJLQDWHG E\ LQGLYLGLXDO V
DVVHVVPHQW DUH H[DPQLHG DV FRQVWDQW V\VVWHPDW
HUURU LQ ZKLFK YDOXHV LQ DVVHVVPHQW UHPDLQV VD
DQG LW DOZD\V KDV WKH VDPH LPSDFW 6\VVWHPDWLFW
RQ WKH SURSHUWLHV WKDW DUH DVVHVVHG SHRSOH V
DVVHVVPHQW LV SHUIRUPHG DQG WKHVH WZR HUURUV
\$FFLGHQWDO HUURU ZKRVH VRXUFH GLUHFWRU VL]H
UHVXOWV LQ D UDQGRP ZD\ SRVHV D GLIIHUHQW VLWXD
QRW RQO\ UHOLDELWLW\ RI DVVHVVPHQW SURFHVV EX
TXDOLILFDWLRQV WKDW QHHGV WR EH SUHVHQW LQ DVV
7KH PRUH DQ DVVHVVPHQW LV DZD\ IURP DFFLGHQWD
UHOLDELWLW\ LV PRUH UHODWHG WR WKH GDWD LWV
DVVHVVPHQWV DQG GDWD FROOHFWLRQ WRRO WKDQ V
\$OJLQD > @ DQG *URXQOXQG DQG /LQQ > @ H[SUHVHV
FROOHFWHG)URP WKLV SHUVSHFWLYH UHOLDELWLW\
IURP WKH DVVHVVPHQWV LQ ZKLFK VDPH PHWKRGV DUH
WKH VDPH HQYLURQPHQW > DQG @ ,Q DSSOLFDWLR
REVHUYHG WKDW UHVXOWV RYHUODSV HYHQ LW LV DS
SURFHGXUH WKH FRHIILFLHQW WKDW LV FDOFXODWHG
WR WKH PRUH UHOLDEOH WKH DVVHVVPHQW SURFHVV
\HDU LW LV H[SHFWHG IURP UHOLDELWLW\ YDOXH WR
RI WKH UHVXOWV FDQ EH FRQVLGHUHG DV VHFUXH 7KH
RI WKH YDOLGLW\ \$Q DVVHVVPHQW WRRO V GHJUHH RI
RI WKHVH WRROV LQ DVVHVVLQJ > @ ,Q DQRWKHU ZRU
WRRO DVVHVVHG LWV LQWHQGHG YDULDEOH ,Q HGXFD
WKH VXFHVV RI WKH VWXGHQWV WKXV DWWDLQPHQW F
YDOLGLW\ YDOXH LV YDOXHGH EHWZHHQ DQG DQG L
PRUH UHOLDELWLW\ RI WKH DVVHVVPHQWV FDQ EH GLV
,Q RUGHU WR ORFDWH HUURU V DPRXQW LWV GLUHF
LV UHTXLUHG WKDW YDOLGLW\ DQG UHOLDELWLW\ RI YD
GDWD FROOHFWLRQ WRROV GDWD DQDO\VLV DQG DOVR
GHVFULSWLRQV DUH YDULHG DPRQJ GLIIHUHQW UHVHD
GHVFULEHG DV KRZ PFK LW VHUYHV WR WKH SXUSRV
5HOLDELWLW\ RQ WKH RWKHU KDQG FDQ EH GHVFULE
GLIIHUHQW PHDVXUHPHQWV LQ ZKLFK VDPH PHWKRG LV
WKH VDPH SRSXODWLRQ > @ 9DOLGLW\ DQG UHOLDEL
WR WKH UHVHDFK EHLQJ TXDOLWDWLYH RU TXDQWL
HPSKDV]HG PHWLFXORXVO\ > @ ,Q TXDQWLWDWLYH U
UHOLDELWLW\ ZRUNV WKURXJK VWUDWHJLHV WKDW LV
JHQHUDOL]HG +RZHYHU FHUWDLQ VWUDWHJLHV VXF
WUDQVIHUDELWLW\ IRU H[WHUQDO YDOLGLW\ JHQHUD
FRQILUPDELWLW\ IRU REMHFWRULW\ DUH VXJJHVWHG
HGXFDWLRQDO ILHOG ZKLFK IRFXVHV SUHVHQWLQJ D I
DQG H[SOLFLW UHVXOWV > @ ,Q WKLV FRQWH[W LQ V
IROORZHG WKDW FRQVLVW YDOLGLW\ DQG UHOLDELWL
DQDO\]H VWXGLHV RQ YDOLGLW\ DQG UHOLDELWLW\ RI
WKH ILHOG RI PDWKHPDWLFV HGXFDWLRQ ZKLFK DGR
DFFRUGDQFH ZLWK WKLV SXUSRVH DQVZHUV DUH ORRN

‡ +RZ DUH WKH YDOLGLW\ ZRUNV RI SRVW JUDGXD
HGXFDFWLRQ LQ 7XUNH\ ZKLFK DUH GRQH EHWZHHQ
WKH &RXQFLO RI +LJKHU (GXFDWLRQ <g. "
‡ +RZ DUH WKH UHOLDELWLW\ ZRUNV RI SRVW JUDG
HGXFDFWLRQ LQ 7XUNH\ ZKLFK DUH GRQH EHWZHHQ
WKH &RXQFLO RI +LJKHU (GXFDWLRQ <g. "

0HWKRGRORJ\

7R H[DPLQH UHOLDELWLW\ DQG YDOLGLW\ VWXGLHV
TXDOLWDWLYH DSSURDFKHV LQ PDWKHPDWLFV HGXFDFW
VRXUFH LWVHOI DQG 'SULQWHG GRFXPHQW' > @ DUH
\$V TXDOLWDWLYH DQG TXDQWLWDWLYH WKHVHV DUHHI
FRQWDLQV WKH WKHVHV WKDW DUH EDVHG RQ TXDOL
WKURXJK GRFXPHQW DQDO\VLV ZKLFK LV RQH RI WKH PH

7KH DLP RI WKH UHVHDFK

,Q WKLV UHVHDFK LW LV DPHG WR H[DPLQH SV\F
GRFWRUD GLVHUWDWLRQV RQ PDWKHPDWLFV HGXFDFW
SDUDGLJPV ,Q FRUOHODWLRQ ZLWK WKLV SXUSRVH Y
GRFWRUD GLVHUWDWLRQV RQ PDWKHPDWLFV HGXFDFW
DQG E\ HPSOR\LQJ TXDOLWDWLYH PHWKRG DUH DQD

6WXG\ *URXS

7KH VWXG\ JURXS LV FRQVLVWHG RI PDVWHU WKH
DUH SXEOLVKHG EHWZHHQ DQG RQ SULPDU\ VF
VFKRRO PDWKHPDWLFV WHDFKLQJ DQG PDWKHPDWLFV H
RQ WKH ZHEVLWH RI WKH +LJKHU (GXFDWLRQ &RXQFLO
JURXS LW FDQ EH VWDWHG WKDW SXUSRVHIXO VDPSOL

'DWD \$QDO\VLV

9DOLGLW\ DQG UHOLDELWLW\ RI WKH WKHVHV WKDW
FRQWHQW DQDO\VLV PHWKRG)LUVW LW ZDV REVHUYHG
WKDW LQ PRVW RI WKH WKHVHV YDOLGLW\ DQG U
/DWHU RQ GDWD JDWKHUG WKURXJK WKHVHV VWXGLH
SUHVHQWHG ZLWK GHVFULSWLYH VWDWLVWLFV DQG LQV
'XULQJ WKH FRGLQJ SKDVH LI D VWXG\ XVHV PRUH W
YDOLGLW\ DQG UHOLDELWLW\ LW LV FRYHUHG LQ DOO
HQVXUH YDOLGLW\ ERWK SHU GHEULHILQJ DQG GDW
DFRUGLQJO\ LQ ERWK FDWHJRULHV 7R HQVXUH UHOL
GDWD LV FRGHG LQGHSHQGHQWO\ E\ UHVHDFKHUV \$P
LQWHUUDWHU UHOLDELWLW\ LV IRXQG DV

)LQGLQJV

\$V D UHVXOW RI DQDO\]LQJ PDVWHU WKHVHV GRFWRUD
7XUNH\ LW ZDV IRXQG WKDW PRUH WKDQ KDOI

GRQH E\ UHVH DUFKHUV IURP *D]L 8QLYHUVLW\ .DUDGH
 8QLYHUVLW\ ,Q RI WKHVH LW ZDV IRXQG WKDW DV
 VWXGLHV DUH SHUIRUPHG ,Q WKH UHVW RI WKHP WKR
 SHUIRUPHG :KHQ PHWKR G FKDSWHUV RI WKH IRUPHU W
 ZDV IRXQG WKDW RI WKH WKHVHV DQG GLVVHUWDW
 SDUW EXW ZLWKLQ WKLV FKDSWHU ,Q UHVH DUFKH
 UHVH DUFKHV YDOLGLW\ LQ RQO\ UHVH DUFKHV UH
 DQG LQ ERWK UHVH DUFKHV DQG WRROV YDOLGLW\ D
 ,Q RI WKH UHVH DUFKHV WKDW KDV YDOLGLW\ DQG U
 GSHQGDELWLW\ DQG FRQILUPDELWLW\ VWUDWHJLHV DU
 FUHGLELWLW\ VXJJHVW FHUWDLQ PHWKR G VXFK DV SU
 WULDQJXODWLRQ SHHU GHEULHILQJ UHYLHZ DQG PH
 VXJJHVW WKLFN GHVFULSWLRQ DQG SXUSRVHIXO VDPSC
 DXGLW WR HQVXUH FRQILUPDELWLW\ VXJJHVW FRQILU
 UHIOH[LWLW\ ,Q WKH WKHVHV DQG GLVVHUWDWLRQV
 WUDQVIHUDELWLW\ GSHQGDELWLW\ DQG FRQILUPDELO
 YDOLGLW\ DQG UHOLDELWLW\ EXW HYDOXDWLRQV ZHU
 WHUPLQRORJLHV
 :KHQ PHWKR GV WKDW DUH XVHG WR HQVXUH WKH YDOL
 LW ZDV IRXQGHG WKDW GDWD WULDQJXODWLRQ :
 GDWD FROOHFWLRQ GHYLFH SHHU GHEULHILQJ UHYLH
 PHWKR GV \$V VHHQ DW 7DEOH WKHVH PHWKR GV DUH
 SURORQJHG HQJDJHPHQW

7DEOH 0HWKR GV WR HQVXUH WKH YDOLGLW\ RI WKH UHVH DUFKHV

Validity of research	Frequency	Percentage
7ULDQJXODWLRQ		
3HHU GHEULHILQJ UHYLHZ		
0HPEHU FKHFNLQJ		
3URORQJHG HQJDJHPHQW		
6DPSOLQJ VWUDWHJLHV		
'HHS IRFXVHG GDWD FROOHFWLRQ		
7KLFN GHVFULSWLRQ		
'HWDLOHG UHSRUW		
3LORW VFKHPH		
5DZ GDWD		
'LUHFW FLWDWLRQ		
'DWD IURP QDWXUDO HQYLURQPHQW		
8VLQJ PXOWLSOH FDVH VWXG\		
&RQILUPDWLRQ DXGLW		
&KDLQ RI HYLGHQFH		

:KHQ PHWKR GV WKDW DUH XVHG WR HQVXUH UHOLD
 ZDV VHHQ WKDW PRVW PHWKR GV IROORZV D VLPLODU S
 XVHG PHWKR G LV SHHU GHEULHILQJ UHYLHZ WKLV
 ZKLFK LV LQ WKH ILUVW SODFH LQ YDOLGLW\ DQ

7DEOH 0HWKRGV WR HQVXUH WKH UHOLDELOLW\ RI WKH UHVHDUFKH

Reliability of research	Frequency	Percentage
3HHU GHEULHILQJ UHYLHZ		
7ULDQJXODWLRQ		
7KLFN GHVFULSWLRQ		
'LUHFW FLWDWLRQ		
3URORQJHG HQJDJHPHQW		
,QWHUUDWHU UHOLDELOLW\		
'HWDLOHG UHSRUW		
0HPEHU FKHFNLQJ		
\$XGLR YLGHR UHFRUG		
6DPSOLQJ VWUDWHJLHV		
3LORW VFKHPH		
'HVFULSWLYH DQDO\JHV		
5DZ GDWD		
&RPILUPDWLRQ DXGLW		
'HHS IRFXVHG GDWD FROOHFWLRQ		
5HOLDELOLW\ FRHIILFLHQW		
&KDLQ RI HYLGHQFH		
&RKHQ\ NDSSD FRHIILFLHQW		

:KHQ WKHVHV RQ GDWD FROOHFWLRQ WRROV YDOLC
 PHWKRGV DUH IRXQG ZLWK WKH WKHVHV WKDW KDYH Y
 PRUH WKDQ KDOI RI WKHVH UHVHDUFKHV SHHU GHEU
 UHOLDELOLW\ RI WKH UHVHDUFK LV XVHG WR HQV
 PHWKRG LV IROORZHG E\ SLORW VFKHPH 'DWD WUI
 WKH YDOLGLW\ DQG UHOLDELOLW\ RI WKH UHVHDUFK L
 YDOLGLW\ RI WKH WRROV ZLWK D QXPEHU RI RQO\ 7D
 ,W LV VHHQ WKDW GLIIHUHQW DSSURDFKHV DUH HF
 UHOLDELOLW\ RI WRROV DUH H[DPLQHG 2Q WKH RWKHU
 WKH YDOLGLW\ DQG UHOLDELOLW\ VWXGLHV RI WKH U
 SDUDGLJP LV VHHQ 6WUDWHJLHV VXFK 6SHDUPDQ
 FRHIILFLHQW &URQEDFK DOSKD FRHIILFLHQW 3HDU
 FRUUHODWLRQ FRHIILFLHQW DUH DOVR VHHQ WR EH HP

7DEOH 0HWKRGV WR HQVXUH WKH UHOLDELOLW\ RI WKH UHVHDUFKH

Tools' Reliability	Frequency	Percentage
,WHP DQDO\VLV		
3LORW VFKHPH		
,QWHUUDWHU UHOLDELOLW\		
&RQVLVWHQFH EHWZHHQ UHVHDUFKHUV		
\$XGLR YLGHR UHFRUG		
0HPEHU FKHFNLQJ		
7ULDQJXODWLRQ		

'LVFXVVLRQ DQG 5HVXOWV

,W LV H[SHFWHG WKDW YDOLGLW\ DQG UHOLDELOLW\ V
VWHS WR WHVW WKH DFFXUDF\ RI WKH VFLHQWLILF UH
LQWHUURJDEOH RI WKH GDWD DQG FDOFXODWLRQV FR
PLQLPDO 'DWD DQG WKH UHDVRQ WR JHW WKHP VKRX
WKHVHV DUH FRQVLGHUHG WR EH WKH ILUVW VWHS LQ
DQG ZLVGRP JDLQHG WKURXJK WKH MRXUQH\ ZLOO GH
SDWK WR FDUYH ,W VKRZV WKDW WKHUH LV D SUREOH
PHWKRG DV UHTXLUHG RU WKHVHV ZLWK WKLV PXFK
UHOLDELOLW\ LQ WKHP \$OVR LQ UHVHDUFKHV RQ YD
GDWD WULDQJXODWLRQ DQG GLUHFV FLWDWLRQ DUH F
EHHQ DWWHQWLYH DV RQH VKRXOG ,W FDQ DOVR EH
EHFDXVH WKH\ UHTXLUH OHVV HIIRUW > @

7KH IDFW WKDW VWUDWHJLHV ZKLFK LV XVHG LQ U
SDUDGLJP VXFK DV .DLVHU ODLHU 2ONLQ .5 DUH IR
SUREOHPV LQ UHJDUGV RI GLIIHUHQFHV DQG DZDUH
YDOLGLW\ DQG UHOLDELOLW\ > @ ,Q DGGLWLRQ WR W
GSHQGDELOLW\ DQG FRQILUPDELOLW\ > @ DQG WKHL
FDQ EH VKRZQ DV D VROLG DQG UHTXLUHG HYLGHQFH
DFWXDOO\ LQFOXGH YDOLGLW\ DQG UHOLDELOLW\ ZRU
UHOLDELOLW\ DUH RIWHQ HPSOR\HG LQ SRVW JUDGXDW
XVHG

&RQVHTXHQWO\ HYHQ WKURXJK PRVW WKHVHV LQFO
SHUIRUPHG LW FDQ EH IRUHFDVWHG WKDW WKH\ DUH O

@ 7KLV FDQ EH VHHQ E\ WKHLU VWUDWHJ\ XVDJH
SUHGLFWLYH DQDO\VLV 7KLV VLWXDWLRQ VKRZV WKDW
ORZ DQG WKLV LV FDXVHG E\ DVVHVPHQW GLIIHUHQF
EHWZHHQ TXDOLWDWLYH DQG TXDQWLWDWLYH SDUDGL
UHOLDELOLW\ ZKLFK VKRZV LI UHVHDUFKLQJ WHFKQL
HOLJLEOH WR EH XVHG VFLHQWLILFDOO\ RQO\ UHPDLQ
SDUDGLJP EDVLV ,W LV DOVR VWULNLQJ LQ TXDUWHU F
DOO

5HIHUUHQFHV

%DúRO * (÷LWLPGH gOoPH YH 'H÷HUOHQGLUPH 3HJ
%D\NXO < (÷LWLPGH YH SVLNRORMLGH |OoPH NODV
g6<0 <D\ŌQODUŌ
&RKHQ / 0DQLRQ / 0RUULVRQ . 5HVHDUFK 0H
/RQGRQ 5RXWOHGJH)DOPHU
&URFNHU / 0 \$OJLQD / ,QWURGXFWRQ WR FOD
<RUN +ROW 5LQHKDUW DQG :LQVWRQ
(UNXú \$ 3VLNRPHWUL •JHULQH \D]ŌODU \$QNDUD 7•
(UNXú \$ gOoHN JHOLúWLUPH YH X\DUODPD oDOŌúŌ
3VLNRORML %•OWHQL
*HOEDO 6 gOoPH YH 'H÷HUOHQGLUPH (VNLúHKLK \$
*URQOXQG 1 (/LQQ 5 / 0HDVXUHPHQW DQG H
1HZ <RUN 0DFPLODQ

+DODG\QD 7 0 7KH &RQGLWLRQV RI \$VVHVVPHQW RI
&RQGLWLRQV RI 3UH .± (GXFDWLRQ LQ \$UL]RQD
(GXFDWLRQ 3ROLF\ 6WXGLHV /DERUDWRU\ DW \$UL]RQD
/LQFROQ < 6 *XED (* 1DWXUDOLVWLF ,QTXLU\
.DUDJ]] < (NLFL 6 6RV\DO %LOLPOHUGH <DSÖÖ
.XOODQÖÖDQ øVWDWLVLVNLVHO 7HNQLNOHU 9H gOoHM
&LOW 6D\Ö
1XQQDOO\ - & 3V\FKRPHWULF WKHRU\ 1HZ<RUN 0F
1XQQDOO\ - & %HUQVWHLQ , + 3V\FKRPHWU
0F*UDZ+LOO
3DWRQ 0 4 4XDOLWDWLYH (YDOXDWLRQ DQG 5HV
&DOLI 6DJH 3XEOLFDWLRQ
5REVRQ & 5HDO :RUOG 5HVHDFK \$ UHVRXUFH IR
UHVHDFKHUV QG (G 2[IRUG %ODFNZHOO
7DQ ù g÷UHWLPGH gOoPH YH 'H÷HUOHQGLUPH 3HJHP
7DQ ù YH (UGR÷DQ \$ g÷UHWLPL 3ODQODPD YH 'H
<D\ÖÖQFÖÖÖN
7HNLQ + (÷LWLP GH gOoPH YH 'H÷HUOHQGLUPH