

Matseno

Mekgwa ya go ruta dipalopalo ya tlwaelo le ditsenogare di akaretša (gomme di nepiša kudu go) go hlaloša teori le go diriša dikgopolo tša mathomo tša dipalopalo. Tše mmalwa di nepiša go kaonafatšeng dikgopolo tše di akareditšwego dithutwaneng tša baithutelatikriri tša bothata. Barulaganyi ba puku ye ba lemogile bohlae bja bokgoni le sekgoba sa bongwadi lenaneothutong la dipalopalo mo dikolong tša thuto ya godimo ya Afrika Borwa. Ba ile ba ikemišetša go oketša mokgwa wa setšo wa teori (le wa tirišo) wa thuto le tšhomišo ya tirišo yeo e šetšwego e šomišetšwe go ditaelo ka kgopolo ye mpsha.

Puku ye e tšwa go protšeke ya go hlola le go beakanya dikanegelo tšeo e sego tša nnete tšeo di theiwego go diteng go tšwa go lenaneothuto la tshekatsheko ya mohlwaela wa kgale Pretoria (UP). Tšweletšo go tšwa protšekeng ye e ka šoma bjalo ka mothopo wa tlaleletšo wa go ithuta woo baithuti ba UP (le ba bangwe) ba ka o dirišago go hlohleletša kgahlego ye nngwe — le go fokotša dikgonono tšeo di dikologilego dikgopolo tše di rutilwego go tshekatsheki ya mohlwaela wa dinako.

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Tshekatsheko ya mohlwaela wa dinako ke thutwana ya ngwaga wa boraro yeo e dirwago ke baithuti ba e ka bago ba 300 ngwaga wo mongwe le wo mongwe, gomme e na le baithuti bao ba tšwago go BSc Mathematical Statistics, BSc Actuarial and Financial Mathematics, BCom Statistics and Data Science, le BCom Economics, gare ga tše dingwe. Dikagare di akaretša mohlwaela wa dinako wa go hlaloša data, thoto ya dipharologanyo tša palogare ya tša kgale tša go ama tše diswa, kakanyo ya dimmitlolo tšeo di akantšwego, kakanyo, le tshekatsheko ya ya di-model tšeo di lekantšwego, ponelopele, le tshekatsheko ya mašaledi.

Ka semestara se tee, baithuti ba ile ba tšea karolo ka boithaopo mo mošongwaneng wa go anega dikanegelo moo dikgopolo tša bohlokwa tša tshekatsheko ya mohlwaela wa dinako di šomišetšwego bjalo ka baanegwa. Baithuti ba ile ba hwetša tlhahlo ye kopana ya go se šitiše, yeo e sego bothata kudu goba tlhahlo ya go ngwala kanegelo ye e sego ya nnete (kanegelo kopana), ka nepo ya go nyakišiša tlhohleletšo ya disenthara tša monagano tšeo di bego di sa hlokomelwe peleng tšeo

di ka emelago disenthara tša mohuta woo go potlakiša go ithuta le go fokotša letšhogo leo le lemogilwego leo le dikologilego tshekatsheko ya mohlwaela wa dinako. Ka tsela ye, bokgoni bja go ruta le dinyakišišo bo matlafaditšwe mo thutwaneng yeo ngwaga le ngwaga e hlohleletšago baithuti ba BCom, kudukudu, ka go hlola didirišwa tša dithuto tša tlaleletšo tša baithuti ba ka moso, tšeo di ngwadilwego ke baithuti gomme di beakantšwe ke bafahloši (banyakišišibagolo mo protšekeng ye). Thuto ya semmušo e akaretšwa ka tsela ya thuto ya semmušo ya magareng ga baithuti ka tshepedišo yeo e thekgago thuto ya boitlhamelo, yeo e theilwego go diprotšeke, le go ithuta ga dikarolo tša go phatlalala.

Ditlhalošo tše dingwe tšeo di hlalošago (Cryer le Chan 2008):

Mohlwaela wa dinako

Data yeo e hweditšwego go tšwa go ditekolo tšeo di kgobokeditšweng ka tatelano ka dinako, gantši ka dikgala tše di lekanago magareng (mohlala, ditheko tša dithoto tša go tswalela tša letšatši le lengwe le le lengwe, lebelo la phefo ka iri, le dipalo tša ngwaga tša dibjalo goba tšweletšo ya diphoofolo). Boleng gantši bo emelwa ke X_t , yeo e laetšago boleng bja mohlwaela wa dinako, gomme setšupo sa t se laetša nako ya tekolo. Ka kakaretšo, go na le lereo la phošo la go oketša leo le šupago ka a_t , yeo e emelago "ka sewela" tšeo di dulago di se a hlalošwa ke mmotlolo ka bowona. Lereo le la phošo la go oketša le dutše le bitšwa "lešata le lešweu".

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Mmotlolo wa dipalopalo woo o šomišago data ya go feta go akanya data ya ka moso

Mokgwa wa mmetse wa mmotlolo wa X_t wo o theilwego go ditekolo tša wona tša go feta, sucs X_{t-1} ; ya tirišo, boela morago X_t ka bowona ka dintlha tša go feta ka nako.

Palogare ya Go sepela

Mokgwa wa mmetse wa mmotlolo wa X_t wo o theilwego go ditekolo tša nako ya go feta ya mareo a phošo go swana le a_{t-1} .

Ditshwano gare ga Tiro (ACF)

Tšweletšo ya dipalopalo yeo e bontšha kamano gare ga ditekolo gare ga

X_t le X_{t-k} , mohlala ge ditekolo go mohlwaela wa dinako X_t di t-k di arogana ka dinako tša go fapafapana.

Ngangišano ya Dickey-Fuller (ADF)

Teko ya dipalopalo ya bohlokwa bja go laola ge e le gore mohlwaela wa dinako X_t o na le modu wa yuniti.

Ditlhalošo tše dingwe tša methopo ye menyane go mareo le dikhutsofatšo ka pukung ye di ka hwetšwa ka go Cryer le Chan (2008).

Nepo

Nepo ya protšeke ye e be e le go thuša kgoboketšo ya dingwalwa tša dikanegelo tšeo e sego tša nnete tšeo di kgathilego tema moo dikarolo le dikgopolo tša kanegelo ya dikanegelo di tšewa go tšwa go didirišwa tša.

Maikemišetšo

Maikemišetšo a protšeke e be e le:

- go kaonafatša go ithuta ga moithuti yo a šomago ka didirišwa tša thuto tšeo di swanetšwego go dirwa;
- Go hlohleletša baithuti go tšea bong ka mokgwa wa go ithomela, ka ga ka moo maitemogelo a bona a thuto a ka thekgwago ka mokgwa wa go ithuta ga badirišani moo go thekgilwego go protšeke;
- go fokotša bogolo bja kgonono le letšhogo ka ga thutwana go \ baithuti ba ka moso; le
- laola go maitemogelo a go tsenelela a go kgatha tema ga moithuti ga diphetogo tša monagano go latela tshepetšo ya boithomelo ya go šogana le dikgonono le maitshwaro a go ithuta ka go diteng tša thutwana.

Dinepo

Dinepo tša protšeke e be e le go:

- kgoboketša, rulaganya, le go lokiša dikanegelo tšeo e sego tša nnete tšeo di ngwadilwego ke baithuti tšeo di tšwago go karolo ya mohlwaela wa dinako;

- phatlalatša kgoboketšo ye ya dikanegelo ka ESI Press bjalo ka puku ya semmušo ya go kgatha tema ga baithuti;
- šomiša sedirišwa se ka go dithutwana tše di sepelelanago gošomišwa ke baithuti le go kaonafatša ka moso;
- tšwetšapele pelo ye e tšweeditšwego ya protšeke ye khonferenseng ya bosetšhaba; le
- kwešiša, ngwala, le go lokiša maitemogelo a go kgatha tema ga baithuti kagokarolotšedintšitšatseboletlaleletšoya boithomelogo thutwana ya boithutelatikrui ya gofimo mo karolong ya dipalopalo.

Go protšeke ye, baithuti ba filwe tshedimošo ka tsela ye:

Ngwalang kanegelo ya mantšu a ka bago 1000 (matlakala ao e ka bago 1.5 a A4) bjalo ka ge o ka re ke "kanegelo ya go robala" ya moratho wa gago goba motswala wa gago o ka bago o na le yena. Kanegelo ye e swanetše go šomiša "baanegwa" go tšwa go karolo ya mohlwaela wa dinako go tšwa go dithuto tša bogolo bja pele. Kanegelo ya gago e swanetše go ba le moanegwathwadi, molwantšhi, gomme e beakanyetšwe lefaseng le e sego la nnete/la nnete/ naga/lefelo la kgetho ya gago.

Dilo tše di itšego tšeo ke tla bego ke di lebelela (eupša o se ke wa dumelela gore di thibele bokgoni bja gago bja go ihlamela):

1. *Go na le baanegwa/mafelo a itšego ao a amanago thwii le dikgopolo tša mohlwaela wa dinako (mohlala, ARIMA(0,1,0) ke molwantšhi!);*
2. *There is a natural link between the story and the course content of time-series; Go na le kgokagano ya tlhago magareng ga kanegelo le dikagare tša thutwana ya mohlwaela wa dinako;*
3. *Kanegelo e hlamilwe gabotse; le*
4. *Kanegelo e fela ka tharollo ye nngwe (moanegwathwadi wa mosadi o fenyja moloi yo mobe, mohlala).*

Ga se gore o swanetše go ba mongwadi yo mogolo go tšea karolo mošomong wo. O hloka fela go ba wena le go nyaka go leka go ba le boitlhamelo bo bonyenyane. Dintlha tše di itšego: O ka ngwala kanegelo ye ka polelo ya gago ya gae, goba ka Seisimane. Ge e le ka polelo ye e fapanego le Seisimane, ke ikana go leka ka maatla go hwetša phetolelo ya maleba go ya go Seisimane. O lokologile go romela dikanegelo tša go feta e tee, efela hle di romele ka go di aroganya.

Mokgwa wo o latelwago ka morago ga go amogela mešomo ya baithuti e be e le go bala, go swayaswaya, le go rulaganya kanegelo ye nngwe le ye nngwe go aga le go lokiša puku ye e kopanego, ye e beakantšwego le go kgatha tema ye e thušago nepo ya mafelelo ya e sego fela puku ya dikanegelo ye e kgathilego tema, eupša e šomago gape bjalo ka sedirišwa sa thuto se seswa seo se sa tšogo hlangwa le go rulaganywa ka gare ga sethuto sa matseno sa tshekatsheko ya dinako. Baithuti ba be ba lokologile go tšea karolo (ga go na go kgatha tema ga kgapeletšo).

Ba be ba swanela go fa tumelelo ye e lego pepeneneng gore dikanegelo tša bona di ka šomišwa mabakeng a dinyakišišo gammogo le tumelelo ya gore go na le kgonagalo ya go ka gatišwa. Go tšwa phaphošing ya baithuti bao ba ka bago 300, go amogetšwe dikgopolo tše di fetago 30, moo baithuti ba 23 ba dumeletšego gore mošomo wa bona o akaretšwe pukeng ya mohuta wo. Barulaganyi ba beakantše dikgopolo ka dikarolo tše pedi tše di fapanego (Karolo ya I: Dinonwanetsholo le Dinonwane le Karolo ya II: Dikanegelo tša Boikgopolelo le tša Saense) go ya ka mokgwa wa kakaretšo le kgopolo ya mošomo wo o rometšwego, wo o sepelelanago le mehuta ye e tumilego ya dikanegelo tše di sepelelanago le dikanegelo tša nako ya go robala.

Khuetšo

Khuetšo ya protšeke e be e le ye e latelago

- Baithuti ba na le mothopo o moswa wa tlaleletšo oketšegilego le go ithuta.
- New students can refer to the experiences of former students, leading to informal peer learning. Baithuti ba baswa ba ka lebelala maitemogelo a baithuti ba peleng, gomme seo sa dira gore go ithuta ga badirišani moo e sego ga semmušo.
- Diteng tša thutwana di ba bohlokwa ka mokgwa wa boitlhamelo, gomme seo se hlohleletša maitemogelo a dikarolo tše dintši go disaense tša tshekatsheko.
- Mo ngwageng wa boraro ka go thuto ya dipalopalo, baithuti ba šoma ka bokgoni bja monagano (go nagana ka boitlhamelo) bjoo bo sa lekolwego gantši mo karolong ye.

Moithuti yo mongwe le yo mongwe o tliša bokgoni bja go ithuta bjo bo fapanego phaphošing ya borutelo (e kgolo goba e nnyane). Ka lebaka leo, go diriša mekgwa ye e fapafapanego ya go ruta go bohlokwa bakeng sa tikologo ya go ithuta ye e šomago gabotse. Šedi, polelo, kgopolo, le go nagana ga maemo a godimo ke dikarolo tše nne (go tšwa go tše tshela) tše bohlokwa tše di amago tshepedišo ya go ithuta. Sedirišwa sefe goba sefe goba tikologo ye e kopanyago dikarolo ka moka tše nne e bohlokwa bakeng sa maitemogelo a go ithuta. Saense ya go anega dikanego tše dibotse e nyaka tše tše nnè ka moka, ge e se tše tshela ka moka tša dikarolo.

Go nepišiša dipalo tša tlhamo ya dikanegelo go ditheknolotši tša dipalo go bile le kgahlego kgauswanyane (Albano le Pierri 2017; D'Andrea le Waters 2002; Lashari le ba bangwe 2022; Sherwood 2018). Se se dumelela baithuti gore ba oketše thuto ya bona lefapheng la temogo ka mabokgoni ao a tiilego ao a šetšego a hweditšwe lefapheng le lengwe. Athekele ye e phatlallditšwego ke Harvard Business Publishing (Peterson 2017) e gateletše saense ya kanegelo ya dikanegelo. Go boletšwe athekeleng ye e rego dikhemikale tša bjoko, tša go swana le kothisololo (homouna ya kgatelelo ya monagano, eupša mo lebakeng le e oketša mošomo wa kgopolo), oksithosini, le dopamaene di a godišwa ge motho a bala kanegelo. Dikhemikale tše tša bjoko di thuša ka go tišetša mogopolo, go boloka šedi, le go laola le go matlafatša dikarabo tša maikutlo.

Dinyakišišo di nepišitše kudu go go šomiša dikarolo tša tirišano le go kgatha tema dikanegelo tše o sego nnete thutong ya pele ga sekontari (Blackburn 2015) le tše dintši thutong ya motheo (Lemonidis le Kaiafa 2019). Banyakišiši ba bangwe ba lemoga gore dikanegelo tše o sego tša nnete di ka tšoša kgahlego, tša fokotša letšhogo, le go hlohleletša go kgatha tema tshepedišong ya thuto (D'Andrea le Waters 2002; Lemonidis le Kaiafa 2019). Thutong ya godimo, go bile le nepišo go dipuku tša diswantšho le bobegaditaba bjo bongwe bja titšitale (Albano le Pierri 2017; Walters et al. 2018). Karanasiou et al. (2021) ba nyakišišitše ditlamorago tša go anega dikanegelo thutong ya godimo. Dikutollong tša bona, go anega dikanegelo go bonwe bjalo ka sedirišwa se se šomago sa go ruta le go ithuta. Go hweditšwe go šoma kaone go baithuti bao ba nago le bokgoni bjo bo phagamego bja go gopola. Karanasiou le ba bangwe. (2021) ba hlalošitše dikanegelo

goba go anega dikanegelo bjalo ka sedirišwa sa go dira gore go be le tlhalošo ya kwešišo ya gago le maitemogelo a gago a go ithuta.

Bontši bja go kgatha tema ga baithuti go ka kgatha tema go dingwalwa tša go anega dikanegelo bjalo ka mokgwa wa go ruta ka gare ga disaense tša tshekatsheko — kudu dithutwaneng tša godimo tša baithutelatikrii tša dipalopalo. Lefaseng leo mathata a lego bothata go a rarolla, dipalopalo e dula e le karolo ya go tšhoša le go se kgahliše ya ka godimo ga dithutwana tša mathomo (Kruppa et al. 2021; Lemieux 2020). Kgahlego ye e ikgethilego ya go utolla dikanegelo tšeo e sego tša nnete go dithuto tša godimo tša dipalopalo tša baithutelatikrii e ka ba motheo wo mongwe (yeo kgatelelo e lego fase) ya go ruta le go ithuta. Kudu, nyakišišo e beakantšha go anega dikanegelo bjalo ka tlhako ya bohlokwa ya go dira poledišano ya dipalo. E dumelela barutiši (bafahloši) le baithuti go abelana tsebo ya nako le nako ye sego ya semmušo le go hlohleletša go ithutana ga maloko.

Johan Ferreira le Seite Makgai, 2023

Methopo

Albano, G. and Pierri, A. 2017. Digital storytelling in mathematics: a competence-based methodology. *Journal of Ambient Intelligence and Humanized Computing*, 8(2): 301–312.

Blackburn, G. 2015. Effectiveness of eLearning in statistics: Pictures and stories. *E-Learning and Digital Media*, 12(5–6): 459–480.

Cryer, J.D. and Chan, K-S. 2008. Time series regression models. In: *Time series analysis: with applications in R*. 2nd Edition. Springer: New York, NY. pp. 249–276.

D’Andrea, L. and Waters, C. 2002. *Teaching statistics using short stories: Reducing anxiety and changing attitudes*. Paper presented at the Sixth International Conference on Teaching Statistics, Cape Town, South Africa, July 2002.

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Karanasiou, K., Drosos, C., Tseles, D., Piromalis, D. and Tsotsolas, N. 2021. Digital storytelling as a teaching method in adult education – The correlation between its effectiveness and working memory. *European Journal of Education Studies*, 8(12): 288–298.

Kruppa, J., Rohmann, J., Herrmann, C., Sieg, M., Rubarth, K. and Piper, S. 2021. What statistics instructors need to know about concept acquisition to make statistics stick. *Journal of University Teaching & Learning Practice*, 18(2): 2.

Lashari, T.A., Sajid, U. and Lashari, S.A. 2022. The effective use of digital storytelling and flipped classroom instructional approach to improve science subjects. *International Journal of Instruction*, 15(4): 221–232.

Lemieux, C. 2020. The use of story-based tasks in post-secondary students’ learning of statistics. Unpublished PhD thesis, University of Calgary, Canada.

Lemonidis, C. and Kaiafa, I. 2019. The effect of using storytelling strategy on students’ performance in fractions. *Journal of Education and Learning*, 8(2): 165–175.

Peterson, L. 2017. The science behind the art of storytelling. Harvard Business Publishing. [Online]. Available at: <https://www.harvardbusiness.org/the-science-behind-the-art-of-storytelling/>.

Sherwood, C.W. 2018. Storytelling and teaching statistics. In M.A. Sorto, A. White, and L. Guyot, (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics*. Voorburg: International Statistical Institute. [Online]. Available at: http://iase-web.org/Conference_Proceedings.php.

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Walters, L., Green, M., Goldsby, D. and Parker, D. 2018. Digital storytelling as a problem-solving strategy in mathematics teacher education: How making a math-eo engages and excites 21st century students. *International Journal of Technology in Education and Science*, 2(1): 1–16.