

# *HE TOHU MAUMAHARA KI A PAORA MATO*



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## HE MIHI

Ka tuku ngā whakaāro tuatahi ki te atua, te toi o ngā rangi, te tīmatanga me te whakamutunga o ngā mea katoa.

E rere ana ngā roimata mō koutou kua wehe ki te pō, ngā mate o tērā marae, o tērā marae, o tērā marae, moe mai rā ki tua o paerau.

Tangi ana te ngākau mōu, e Paora, i wehe wawe ai ki tua o te ārai. E kīia nei te kōrero, ko te au o te moana, e taea te karo, ko te au o Aituā, tē taea. Ahakoa kāore tāua i tūtaki kanohi ki te kanohi i te ao kikokiko nei, ko tō wairua i ārahi i ahau ki ēnei mahi.

Ka nui hoki te aroha ki a koutou o tōna whānau, ōna hoa e noho ana i raro i te kapua o te pōuri. Ko te tūmanako he hikinga ngākau tēnei whakatakahanga i ēnei wā uaua.

Me mihi ka tika ki a koutou o Ngā Pae o te Māramatanga, nā koutou tēnei kaupapa i hiki, i whakaora kia taea ahau ki te kōkiri i tēnei ara. Nā koutou hoki i whakatūwhera i ōku karu ki ngā āheinga o te rangahau Māori i ngā rā o Anamata.

Me mihi hoki ki Te Whare Wānanga o Waikato, nā rātou i whakaāe kia whakamahi i ngā taiwhanga pūtaiao me ngā hangarau e oti ai te mahi.

E kore e mimiti ngā mihi ki a kōrua ōku kaitiaki, ā Kim rāua ko Te Taka, i ārahi i ahau i tēnei ao hou o te rangahau. Nā ō kōrua kupu tautoko me ngā wānanga maha i whakahihiko i ahau ki ēnei mahi, ki ngā mahi o āpopo hoki.

Kaua ahau e wareware ki a koutou i parahia te huarahi māku ki ēnei mahi. Ka mihi ki a Christian rāua ko Dalour, i a kōrua ringa rehe i te ao Pūtaiao, ka mihi hoki ki tōku Pāpā, i āwhina i ahau ki ngā mahi whakaoti me ngā tikanga whakairo.



## WHAKARĀPOPOTONGA

Karanga rā, karanga rā! Kua hinga te tōtara i te wao nui a Tāne! Haruru ana te whenua i te tini o iwi, i te mano o tangata e noho mokemoke ana ki tēnei taniwha hikuroa a Paora Mato. He tohu aroha, he tohu whakamaumahara tēnei whakatakahanga mōna i wehe wawe ai ki tua o te ārai. Kua hangaia i ngā rā tata nei he tekoteko mō tētahi taonga hei whakawhiwhinga ki te whakataetae “Hīkoi in Hune”. Heoi, ehara tēnei i te tekoteko i whakairohia ki ngā hangarau o kui mā, o koro mā, he mea i tāngia kē mā te hangarau o nāiane, mā te mīhini tā ahunga toru. Ko te ao e noho nei tātou he ao hou, he ao hurihuri, he ao hangarau. Kāore e ārikarika ngā whanaketanga o te ao Pūtaiao i ngā tau kua pahure, e tipu matomato ana ngā hangarau me ngā matū hou. Ko te kaupapa matua o tēnei mahi he whakatewhatewha i ēnei pūtaiao hou, he toro i ngā ringa ki ngā rākau o te Pākeha, ki te whakaputa i tētahi tāonga Māori whakaharahara, me mau hoki te ngākau ki ngā tāonga o ngā tīpuna. Ko te āhua o te tekoteko he mea i koha mai e te whānau o Paora Mato, he tekoteko i whakirohia ki tōna kī rāwhānau 21. I matawaitia, i etitatia te kī kia puta he āhuahanga matihiko mō te tekoteko. Ko te matū o te tekoteko i hangaia mā te muka harakeke me te kirihau pōpopo (PLA) kia tiaki tonu i a Papatūānuku. I whakaotihia te tekoteko mā te peita ki te paru parauri me te whero “Jarrah”, nō Feast Watson, ka tāpirihia he karu pāua kia whakaōrite ki ngā whakairo tūturu. Ko tētahi tino wero o tēnei kaupapa he whakauru tikanga ki ngā mahi. He nui tonu ngā mea hei whakaārohia, hei wānangahia i mua i te whakatau i te huarahi tika mō ēnei mahi.

## WHAKATAKINGA

I te marama o Hune, 2021, i hinga tētahi tōtara i te wao nui ā Tāne. Ka maumaharatia ia mō tōna kaha ki te whakawhanaunga, ki te whakahoahoa me te marea. Ka maumaharatia mō tōna pakari, mō tōna toa ki te hākinakina. Ka maumaharatia ia mō tōna hīkaka ki te whai i te mātauranga, mō ōna tohu maha. Ka maumaharatia ia e tōna whānau, e ōna hoa, e te hāpori whānui.

I te marama o Hune, 2021, i tū tētahi whakataetae, ko “Hīkoi in Hune” te ingoa. Ko tōna kaupapa, he akiaki i te hāpori ki te kori tinana mā te ine i ngā takahanga o te tangata, kia kite i te tawhiti o tōna hīkoi. I mua i tōna matenga, he kaiwhakataetae a Paora ki tēnei kaupapa. I puta te whakaaro i tētahi o ōna hoa kia hangaia he taonga whakamaumahara i a Paora hei whakawhiwhinga i roto o “Hīkoi in Hune”, nā tērā tēnei kaupapa i ara ake.

Nā te whānau o Paora i koha mai te āhua o te taonga: he tekoteko e takoto ana ki runga i te kī rāwhānau 21 o Paora (Whika 1).



*Whika 1: Te Kī Rāwhānau 21 o Paora Mato*

Kua whai wāhi ahau i ngā wiki kua pahue nei ki te tiro tiro haere i ngā kete mātauranga o ētahi mātanga pūtaiao, kia whakatewhatewha i ngā hangarau me ngā tukanga o te ao hou. Ko te aronga matua o tēnei mahi, he ako mō tēnei mea te tā ahunga toru, arā, ko te “3D Printing”. He nui ngā pūkenga o ngā kairangahau e āmio ana i ahau ki ēnei mahi, kua hangaia hoki e rātou he huarahi hei whakaputa aho tā ahunga toru mai i te harakeke. Ko tāku mahi he mātakitaki, he ako, he āwhina i ēnei tukanga, ka whakamahi i te aho harakeke ki te tā i te tekoteko mō te taonga.

E toru ngā wāhanga matua o te hanga i tēnei taonga. Tuatahi, ka whakaāhuahanga i te tekoteko mā te matawai me te whakamamati i te kī 21. Tuarua, ka hanga i te aho tā mā te harakeke me te PLA. Hei whakakapi, ka tāngia te tekoteko mai i te whakaāhuahanga me te aho tā. He nui ngā wero o tēnei kaupapa, he nui hoki ngā hua ka puta. E whai ake nei, ka āta wetewetehia ngā takahanga, ngā uauatanga me ngā pānga o tēnei kaupapa autai.

## TE HANGA I TE TEKOTEKO

### TE WHAKAĀHUAHANGA

Ko tētahi o ngā wāhanga matua o te tā ahunga toru te tauira ka whakamahia e te mīhini kia tā i ngā kape. I te nuinga o te wā, ka noho ēnei tauira hei kōnae ahunga toru .STL, .OBJ rānei. Ka pupuri te kōnae .STL i te āhua ahunga toru o tētahi mea mā te huri i tōna āhua hei kohinga tapatoru. Ka pānuitia ēnei tapatoru e te rorohiko, ka whakaāhua anō i te tauira i runga i tōna mata, i runga rānei i te mīhini tā ahunga toru. Kua tapaina e au tēnei tauira ki te ingoa ‘āhuahanga matihiko’ mō tēnei ripoata. I matawaitia te kī rāwhānau 21 o Paora (Whika 1) mā tētahi mīhini matawai taiaho, ka puta i tērā he kōnae .STL e pupuri ana i te āhuahanga matihiko o te kī (Whika 2). Nui ake i te toru miriona ngā tapatoru i whakamahia e te mīhini ki te hanga i te āhuahanga nei.

He nui ngā hapa o te āhuahanga matihiko nei: I mau tonu te tēpu me te tūārongo o te kī ki te tekoteko, i puta hoki ētahi momo mirumiru i runga i a ia me te huna i ngā whakarei. I whakatikahia ēnei raru mā ngā pūmanawa rorohiko e toru: ko te Solidworks, te Blender me te Flashforge.



Whika 2: Te Āhuahanga Matihiko o te Kī



He painga, he uauatanga tō ia pūmanawa. Ko te painga o te Solidworks, ka taea te huaki kōnae STL hei āhuatanga māmā ki te ētita, he māmā hoki ki te hanga āhua hou me ngā inenga tika rawa. Heoi, ka kaha pakaru ia ki te nui rawa tō kōnae. Kīhai a Solidworks i taea ki te huaki i te āhuahanga matihiko o te kī nā te nui o ngā tapatoru ki tōna mata, engari i taea ki te tārua i te matauri o te tekoteko, ka hangaia he tuarā mai i tērā kia mātotoru ake te tekoteko, kia taunaki hoki i tōna tū. Ehara a FlashForge i te pūmanawa mīharo mō te ētita, engari he māmā ki te whakamahi, he māmā hoki ki te tapahi āhuahanga matihiko. Nā FlashForge te tūāpapa o te kī i whakawehe mai i te tekoteko, i tangohia hoki ngā mirumiru o runga. Ko Blender te pūmanawa pai rawa mō tēnei mahi i whakamahia e au. He nui ngā taputapu i tino āwhina ki te whakatika i te tekoteko, engari nā te uaua ki te ako mō ēnei taputapu he nui hoki te maumau wā. Nā Blender i whakapiri i te tuarā ki te kanohi o te tekoteko, i whakatika hoki i ngā motu mai i te FlashForge. Ka kitea te āhuahanga matihiko whakamutunga ki Whika 3. Arā noa atu ngā pūmanawa rorohiko mō te ētita āhuahanga matihiko, engari koinei ngā mea i wātea ki te whakamahi mō tēnei hinonga. He pai noa tēnei āhuahanga matihiko ki te tā kape iti me te kape nui whakamutunga, heoi, ki te whai wā anō ki tēnei kaupapa, he nui tonu ngā wāhanga me whakapai ake.

Whika 3: Te Āhuahanga Matihiko o te Tekoteko

## TE AHO

Ko te aho tā te matū ka whakamahia e te mīhini tā ki te hanga i ōna taonga. I te nuinga o te wā ka whakamahia he aho kirihau rewarau nā te māmā o te rewa me te tā, heoi, nā te kino o te kirihau mō te taiao, kei te kaha rangahau ngā mātanga o te ao pūtaiao i ētahi matū pōpopo, matū ahu i te tipu hei whakamahi kē (Stoof et al., 2017). Ko te hanganga matua o ēnei momo aho he matū pupuri mai i tētahi kirihau pōpopo rite ki te PLA (polylactic acid), ka whakakāia ki te kaka tipu kia whakapai ake i ōna āhuatanga matū (Bhagia et al., 2021). Kua puta kē ētahi o ēnei aho pōpopo ki ngā toa. Kei Te Whare Wānanga o Waikato ētahi kairangahau e hanga ana i tētahi aho pōpopo mai i te PLA me te harakeke, nā rātou ahau i ārahi ki te hanga i te aho tā mō te tekoteko nei. Nā te poto o te wā, kāore ahau i whai wāhi ki te mahi i ngā takahanga katoa, engari i āwhina ahau ki ētahi o ngā takahanga, i mātaki i ērā atu takahanga kia whai māramatanga mō te tukanga katoa.

Ka tīmata tēnei whakamāramatanga ki te whakapapa o te aho kia mārakerake te kite i ngā tukunga iho o ia takahanga.

IO-MATUA-KORE = WHAEA RIKORIKO

RANGINUI = PAPATUĀNUKU

TĀNE MĀHUTA = PĀKOKI

HARAKEKE

MUKA = KONUTAI WAIHĀ (NaOH)

MUKA TARAPĪ = HAITORANA ŌKAI-RUA (H<sub>2</sub>O<sub>2</sub>)

MUKA TEA

MUKA PEREHUNGA = KIRIHĀU PŌPOPO (PLA)

HIATO MUKA-KIRIHĀU PŌPOPO

AHO MUKA-KIRIHĀU PŌPOPO



Whika 4: Te Aho Muka me te PLA

Ko te rautaki i whāia ki te hanga i te aho nei he mea i rangahaua e Pickering mā (Stoof et al., 2017). Ka tīmata tā rātou tukanga ki te muka. Ka whakaritea te muka mā te tapatapahi i ngā kaka mā te pororere. Ka whakakāia tētahi ipu ki te muka me te mehanga konutai waihā (Sodium Hydroxide) 10%, he konutai pākati pungatara (sodium sulphite) 2.5% hei whākōkī me te wai, ka raua tahi ki tētahi mīhini pūnakunaku. Ka āta wera haere te mīhini ki te 160°C, ka noho ki taua pāmahana mō te rua haora. I roto o te mīhini pūnakunaku, ka tangohia e te konutai waihā ngā para toenga me te kaku mai i te muka, ka tīmata hoki ki te whakawehewehe i ngā paihere, ka puta he muka tarapī. Ka horoia, ka whakamaroetia te muka tarapī, kātahi ka whakakōmātia mā te waiho ki tētahi mehanga haitorana ōkai-rua mō te 15 miniti i te 70°C, ka puta he muka tea. Ka horoia i te wai, ka whakamāroetia te muka tea ki tētahi umu, kātahi ka whakahanumi ki tētahi pehu kawhe kia whakawehe i ngā paihere, kia perhunga te āhua. Ka rewatia te PLA ki tētahi mīhini whakapūhui i te 180°C, ka āta tāpiri i te muka perhunga me te whakaranu i te 40 rpm mō te 12 miniti, ka puta he hiato muka me te PLA. Ka waruhia te hiato nei kia maramara haere, ka rau atu ki tētahi mīhini whakawhetē aho kia puta te aho muka me te PLA. Ki waenga o ia takahanga i waihotia ngā whakaputanga ki tētahi umu kia maroke rawa i mua i te tīmata i te takahanga o muri. Ko te take mō tēnei, ki te uru he wai ki te ranunga mai i te kōhauhau ka puta he aho kōputaputa, ka tino whakararu i te tā. Ko tētahi atu raru o te aho ka ara i te whakawehe paihere. Ki te nui rawa ngā paihere ki roto i te aho ka kūkā i te mīhini tā, e kore te tekoteko e oti. Ko te whakautu ki tēnei raru he kaha whakawehe mā te pehu kawhe mō te wā roa ake, he tini hoki i te rahi o te āputa o te mīhini tā. Ka kitea te aho whakamutunga ki Whika 4.

## TE TĀ

I ngā tau kua pahure tata nei, kua puta mai ngā rautaki, ngā hangarau me ngā rauemi maha e hāngai ana ki tēnei mea te tā ahunga toru. Ko te tā “Fused Deposition Modelling” (FDM), tētahi o ēnei rautaki. Ka kumea e te mīhini tā FDM he aho kirihau ki tētahi umu, ka rewahia. Ka āta maringi te aho rewa mai i tētahi āputa ki te tūapapa o te mīhini, ka tāngia te papa tuatahi o te taurira. Kia mutu taua papa, ka tāngia te papa tuarua ki runga i te papa tuatahi, ka haere tonu tae noa ki te mutunga o te taurira. Koinei te rautaki i whakamahia ki te tārua i ngā kape haehae o te tekoteko.



E rua ngā take mō te tā kape haehae i mua i te tā i te kape matariki o te tekoteko. Ko te take tuatahi, he uaua ki te kite i ngā hapa o te āhuahanga matihiko ki runga i te rorohiko, heoi, ka tino whakararu ēnei hapa i te tā o te taurira. Mā te tā kape haehae ka kitea ngā wāhi whai hapa o te āhuahanga matihiko kia taea ki te whakatika.

Ko te take tuarua mō te tā kape haehae he whakatika i ngā taurangi o te mīhini tā. Ka taea e te tangata te whakahaere i te tere o te tā, te wera o te mīhini, te mātotorutanga o ia whakapaparanga, te nama o ngā kiri o waho, te kīato o roto, te nui o te kōrere aho, te ahunga o te tekoteko me ngā taurangi maha atu anō kia whakapai i te kōunga o te tā. Kia pai te āhua o waho o te tekoteko, me whīroki rawa ngā whakapaparanga, me pai hoki te rere o te aho kei ngāekieki te aho ki runga i te mata o te tekoteko, kei purutiti rānei te mīhini.



*Whika 5: Te Kape Tuatahi o te Tekoteko*

Kei te whakaahua i te taha mauī (Whika 5) tētahi o ēnei kape haehae. Nā te tā takoto i te tekoteko, he uaua ki te kite i ngā whakarei, kāore hoki e pai tōna tū.

Ka kitea te kape whakamutunga ki Whika 6. I tāngia me te aho muka-PLA mā tētahi āputa 0.75 mm te rahi. He 0.1 mm te mātotorutanga o ia paparanga, e toru ngā kiri o waho, 10% te kīato o roto, 50°C te wera o te tūapapa, ā, 210°C te wera o te mīhini whakaputa aho. He wāhanga tautoko i tāngia ki raro i ngā waewae, ki raro hoki i te kēkē kia kaua te aho e taka i ā ia e tā ana, kei whakararu i ngā whakapaparanga. I tāngia hoki e whā ngā “panekoti” ki te paparanga tuatahi kia pai ai te rere o te aho. He pai te āhua o tēnei tānga, heoi, mā te whakatikatika i ētahi wāhanga e āhei ana ki te whakapai ake i tōna āhua o waho.

*Whika 6: Te Kape Whakamutungai o te Tekoteko*



## TE WHAKAOTI

Ki te āta titiro ki te kape ki Whika 6 ka kitea he nui ngā rārangi e whiti ana i te mata o te tekoteko, he mate āpiti o te tā FDM. He tino mā hoki te tae o ngā kape harakeke me te PLA nā te tae o te muka, me te aha, he rerekē rawa ki te āhua o te



whakairo tīmatanga (Whika 1). Ehara tēnei i te mea kino rawa, he pai tonu te āhua o te tekoteko, engari ko tētahi o ngā whāinga o tēnei tukanga kia hanga ōrite te āhua o te tārua ki te āhua o te whakairo, anō nei i tāraia te kape i te rākau. Ko tētahi o ngā rautaki i whakamahia, he tāpiri i tētahi wāhanga o te tipu, te “lignin”, ki te aho kia parauri ake te tae (Whika 7).

*Whika 7: He aho 10% muka me te lignin: 1% lignin ki waenga, 2% lignin ki te taha matau*

Heoi, i tini tēnei i ētahi o ngā āhuatanga o te matū, i uaua rawa ki te whakatetē me te tā i te aho. Ko te rongoā i kimihia mō tēnei he peita i te tekoteko kia parauri. I whakamātauhia hoki te peita whero me te wai whero hei hokinga mahara ki te kōkōwai i pania ki ngā whakairo o onamata (Whika 8). He nui ngā hangarau hou atu i te FDM ki te tā kōnae .STL e pai ake te ariari o te tekoteko (All3DP, 2018), ka taea hoki ki te whakaōrite rawa i te tānga ki te rākau (Peters, 2021). Ki te whai wā anō, me tūhura pea i ēnei hangarau ki te whakawhanake i te tekoteko whakamutunga.



*Whika 8: Te Whakaoti mā te wai whero “Scarlet” nō Rit (mauī), te paru “Walnut Brown” nō Wattyl (waenga) me te peita whero “Pōhutukawa” nō Resene (matau)*

Mō te tekoteko whakamutunga, i whakamahia he paru parauri me te whero, te “Jarrah” nō Feast Watson (he kape haehae ki Whika 9), i tāpiri hoki he pāua ki ōna karu hei whakaōrite ki te whakairo tīmatanga, ki ngā tekoteko o te marae anō hoki.

*Whika 9: Te Whakaoti mā te paru “Jarrah” nō Feast Watson*



*Whika 10: Te Tekoteko*

Ka kitea te tekoteko whakamutunga ki te whakaahua o runga nei (Whika 10). Mā te wā, ka āpiti atu ki tētahi taunga rākau, ka tāpiri hoki he papa ingoa kia oti te tohu. Kua mau hoki ki ngā Tāpiritanga o raro te āhuahanga matihiko o te tekoteko hei rauemi tautoko i te ripoata.

He tekoteko tino hirahira tēnei, tuatahi mō tōna whakamaumahara i a tātou ki a Pāora Mato me ōna whakatūtukinga maha, heoi, he mea nui hoki ngā tukanga me ngā matū i whakamahia i tōna hanganga ki ngā pūtaiao me ngā toi Māori o āpopo. Nā ngā mahi whakaoti i te tekoteko he ōrite tōna kiri ki te rākau, anō nei i hangaia tēnei tekoteko mā te whao me te patu o te whakairo. Ka kitea i tēnei he nui te pitomata o te hangarau tā āhunga toru. Ehara te rākau i te matū ka ora mō āke tonu atu, nā, ka tāea pea ki te hanga kape o ō tātou whakairo tawhito kia mauhanga i tōna āhua ahunga toru, kei ngaro i te kitenga kanohi. Ka taea pea ki te hanga kape mō ngā whare pupuri taonga kia whakahoki i ngā tāonga tūturu ki ō rātou kainga. Kāore e ārikarika ngā āheinga mō te anamata o tēnei mahi. Heoi, me maumahara tātou, he tauaro rawa tēnei mea te “tā ahunga toru” ki te whakairo. Kō tā te kaiwhakairo mahi, he kai i te rākau anō nei he iro, he *tango* kongakonga mā te whao kia puta he āhua. Ko tā te mīhini tā āhunga toru mahi, he *tāpiri* papanga kia hanga āhua, ka whakataurite a Taepa (2017) ki te mahi hanga whare a te pī, nā tērā ka karangahia e ia tēnei mahi ki te ingoa “whakapī”.

He tauaro ngā tukanga o te whakairo ki te tā ahunga toru, me pēhea rānei ngā tikanga? Ko tētahi o ngā wero nui o tēnei whakatahanga he whakauru whakaaro Māori, tikanga Māori ki ngā mahi. Kāore he tino tauira hei whai mō te whakauru tikanga ki te tā ahunga toru me te hanga aho pōpopo, nōreira i āta mātaki, i āta matapakihia ngā mahi kia kimi rautaki e pai ai te whakauru i ngā whakapono o te ao Māori ki ēnei mahi Pūtaiao o te ao Pākehā. He pai ki te kite he nui ngā tikanga e

whakamahi kē ana ngā taiwhanga pūtaiao kia haumarū ai te tangata, hei tauira: me kaua e kai ki te taha o te mīhini tā ahunga toru, i te taiwhanga pūtaiao rānei. He mea whakanoa, he mea whakaparu hoki te kai i ngā matū, nōreira he tika kia waiho ki waho. Kāore pea i whai whakaaro ki ngā tikanga Māori i te hanganga o ēnei tikanga whakahaumarū, heoi, e ai ki a Temara (Ngāpo et al., 2011), “Ko te tikanga te kaitohutohu i te huarahi tika e pai ai te whakahaere a te Māori i a ia anō.” Ko tētahi wāhanga o tēnei he whakahaumarū i te tangata, i te mahi, nōreira he tīmatanga pai tēnei. Ko te wāhanga nui i mahue i ēnei tikanga haumarū mō te ao Māori ko te karakia. Ehara ahau i te tohunga karakia, heoi, i ngana ahau ki te whakauru karakia ki ētahi wāhanga o te tukanga. Nā te poto o te wā kāore i taea ki te whai i ngā tukanga mai i te tīmatanga ki te mutunga, i pekepeke haere ki ngā tukanga rerekē kē, nōreira he uaua ki te “tīmata” ki te karakia i ētahi wā. Heoi, i huakina te kaupapa ki te karakia, ka whakakapia hoki ki te karakia hei te wā ka koha atu i tēnei taonga ki “Hīkoi in Hune”. Mō te hanga aho harakeke me te PLA, ki te whai tikanga Māori, me karakia i mua i te kato i te harakeke mō ngā mahi, heoi, ka hokona te muka e te taiwhanga pūtaiao mai wāhi kē, nōreira ka pai ake pea kia karakia i te whakawhiwhinga o te muka, i mua i te tīmata i ngā tukanga. Kāore anō ahau kia whakatau mōku anō mehemea me karakia i mua i te tā ahunga toru. I te tānga tuatahi, kāore ahau i karakia, nā, i āhua taumaha te wairua. I te tānga tuarua, i tīmata ki tētahi karakia whakairo, ko te “Rāta Ware”, kātahi te mīhini tā ka ngana ki te peke iho i te tēpu, ka whakararu rawa i te tā. He tohu pea tēnei kia kaua e whakawhiti i ngā tikanga whakairo me ngā tikanga tā ahunga toru nā tō rāua kōaro. I ngā tānga o muri i tēnā, kāore he tino raru ki te whakamahi karakia rerekē, ki te kore karakia rānei. He kaupapa pea tēnei hei rangahau tonu, hei tirohanga mā ētahi mātanga.

I kitea tētahi atu putanga whakakata mō tēnei kaupapa i ahau e tiro tiro ana i ngā papakupu Māori, e kimi ana i ētahi kupu āhua mō ngā mahi i roto i te hanganga o tēnei tekoteko. I puta mai ētahi kupu rongonui e toru. Ko te āhua o ngā tapatoru maha o te āhuahanga matihiko he miriona rārangi iti kua rārangahia ki te āhua o te tekoteko, anō nei he hīnaki, he kete, he “tāiki” rānei. Ki te whakaatu i te piri o te PLA me te muka ki te hanga i te aho, i te piri hoki o ngā paparanga ki te hanga i te tekoteko, i puta mai te kupu “hui”. Ki te whakaatu i te hono, i te whakaroa o ngā kaka muka ki te aho me te hanga tāpiri o te tekoteko, i puta mai te kupu “haumi”. Hei whakarāpopoto whakato i te hanganga o tēnei tekoteko: “Haumi e, hui e, tāiki e!”

## WHAKAKAPINGA

Pūkana mai ana ngā whatu, whētero mai ana te ārero, ka haka te tekoteko ki runga i tōna taunga. He tohu maumahara tēnei tekoteko ki a Paora Mato, he rangatira i hinga i tēra tau tonu, mō te rōpū “Hīkoi in Hune”. 18 henemita tōna teitei, mā te wā ka tū i runga i tētahi wāhanga rākau, ka tāpirihia he papa ingoa kia oti te taonga. I hāngaia tēnei tekoteko e te mīhini tā FDM, ko te matū i whakamahia he hiato muka me te PLA. Kua peitahia ia ki te paru parauri “Jarrah” nō Feast Watson, kua tāpiri hoki he pāua ki ōna karu kia whakaōrite ki te āhua o te tekoteko i runga i te kī 21 o Paora Mato, te tauira i whakamahia ki te hanga i te āhuahanga matihiko o te tekoteko. He hirahira te hanganga o tēnei tekoteko mō te ao Māori, mō te ao Pūtaiao hoki. Ko te moe o ēnei ao e rua ki te whakaputa toi Māori o nāianei tētahi whakatūtukinga nui o tēnei whakatakaranga.

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## TĀPIRITANGA

I tuhia he ripoata anō mō tēnei kaupapa hei tuku ki Te Whare Wānanga o Waikato mō tētahi o ōku pepa. He ōrite ngā kōrero o roto, heoi, i tuhia i te reo Pākehā nōreira kua whakapiri ahau ki tēnei tuhinga hei rauemi āwhina. Kua whakapiri hoki i te kōnae STL o te tekoteko.

## TE WHAKAPĀKEHATANGA O TE RĪPOATA

### EXECUTIVE SUMMARY

This summer internship was organised by Dr. Te Taka Keegan to be a Ngā Pae o te Māramatanga Named Internship supervised by Dr. Kim Pickering at The University of Waikato. The project was called “He Tohu Maumahara ki a Paora Mato” and involved the creation of a 3D printed Tekoteko with a harakeke based biodegradable filament for a trophy in memory of Paora Mato, a staff member at The University of Waikato who unfortunately passed away last year in June. The design for the tekoteko was taken from a figure carved on Paora’s 21<sup>st</sup> key, scanned and edited to become a standing figure reminiscent of the tekoteko perched on the gables of a marae. An 80% polylactic acid (PLA) and 20% harakeke fibre composite was made for the filament and used to print the tekoteko, which stands at 18 cm. Post-processing techniques such as sanding and staining the tekoteko were researched and carried out in order to produce an aesthetically pleasing piece. From a Māori perspective, this project poses many questions about tikanga, traditional practices and contemporary art and is a stimulating topic for more discussion.

## TECHNICAL WORK COMPLETED AND CONTRIBUTIONS

### ACTIVITIES, METHODS AND PROCESSES

#### SCANNING AND DIGITISING THE MODEL

The design for the tekoteko was taken from a figure carved on Paora's 21<sup>st</sup> key (see fig. 1 below).



*Figure 1: Paora Mato's 21<sup>st</sup> key, featuring carved figure*

With permission from his family, the key was scanned using a laser scanner to get an STL file (fig. 2), from which the final model originated.



*Figure 2: STL of key*

There were a few errors from the scan on the STL, one being the base of the key and the table it was placed on were included in the scan. The second were the bubbles seen in fig. 3. These "bubbles" were caused by the dark areas on the key, the areas where the stain seeped into the design the most, which were difficult for the scanner to pick up.



*Figure 3: Errors in STL highlighted in red*

The base of the key was digitally removed using FlashForge, and the resulting figure traced around using splines in Solidworks to create a back. The traced back was extruded and filleted, then added to the front of the Tekoteko in Blender. Unfortunately, just adding it did not attach it and in fact resulted in non-manifold errors, so many hours were spent sewing together the front and back of the tekoteko to reduce the number of problems in the printed models. The inside of the tekoteko was a mess of triangles that caused the printer to print solid areas instead of the usual infill throughout it. Some of them may have been a result of FlashForge inefficiently cutting off the “bubbles” from the model, but the rest had no known explanation. Using Blender, the triangles inside the model were deleted one by one, sometimes line by line, to fix the errors showing up in the printed models. Once all the errors were fixed and the model printed well, the STL (fig. 4) was used to print the final tekoteko for the trophy.



*Figure 4: Final STL model of tekoteko*

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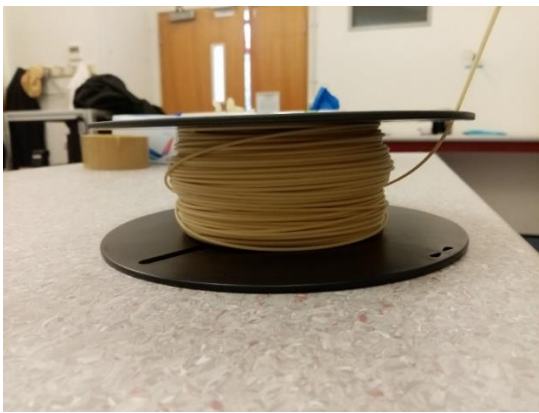
#### MAKING THE FILAMENT

The following procedure was developed at The University of Waikato by Pickering and others (Stoof et al, 2017).

The process used to make the filament started with stripped harakeke fibres, known as “muka” in Māori. The long fibres, which could be up to and sometimes more than 1 m in length, were chopped up using a guillotine and placed in canisters

with a solution of 10% sodium hydroxide, 2.5% sodium sulphite and water. Each canister could hold 80 g of fibre and 1 L of the solution, and four canisters were prepared for each load. The canisters were placed in a digester, which was gradually heated to 160°C then kept at that temperature for 2 hours. The fibres were then removed and washed until they were found to be pH neutral, then dried in an oven for a few days. The dried fibres were bleached with a high percent hydrogen peroxide, water and sodium silicate solution, with 3 L of solution needed for each 45 g of fibre. The bleach was held at 70°C and the fibres left in there for 15 minutes. The fibres were again removed, washed with water and dried. Using small amounts at a time, the dried fibres were “fluffed up” by using a coffee grinder to separate the fibre bundles. The finished fibres were again placed in an oven to dry, and some PLA was also put in to dry. The dry PLA and fibres were mixed together into a homogeneous material with a ratio of 80% PLA and 20% fibre using a melt compounder at 180°C and starting at 20 rpm until initial mixing was complete, then speeding up to 40 rpm for 12 minutes. The melt compounder could only hold 50 g of material at a time, so 5 batches were done to get approximately 250 g of material.

The composite was granulated then dried again before being put into a single screw extruder to produce the filament (fig. 5).



*Figure 5: 20% Harakeke and 80% PLA filament*

Some testing was done with the filament before making the final one. The light colour of the filament resulted in an off-white tekoteko, which, while not unattractive, made the designs hard to see. Attempts to make the filament darker included adding 1-2% lignin (fig. 6), which gave a good colour but changed the rheology and gave difficulties in extruding and printing the filament, and trying to “burn” the fibres by leaving them in the melt compounder at higher temperatures and for longer periods of time, which was unsuccessful but interestingly proved the high thermal stability of harakeke fibres.



*Figure 6: Filaments with 1% lignin - 0% Harakeke (left), 1% lignin – 10% Harakeke (centre) and 2% lignin – 10% Harakeke (right)*

In the end, due to time constraints, it was decided that post-processing would be carried out to change the surface colour of the model rather than try change the filament.

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## PRINTING THE MODEL

A M2 MakerGear 3D printer was used to print models for this internship. Many draft models were printed before the final model to test the printing parameters, the tekoteko STL and the filament to optimise the final appearance (see fig. 7 below).



*Figure 7: Some of the test prints, unfinished prints on right either due to clogging or time constraints*

The STL needed to be tested the most because errors could sometimes be hard to see on the computer but had obvious effects on the print, which could be used to troubleshoot the model. The filament was tested to check its colour and printability. If the filament clogged the printer while printing a small model, it did not bode well for the printing of the large models. The nozzle diameter was changed as needed for the filament to print well, and the filament itself was changed if there were any other problems. Printing parameters such as printing speed, extruder temperature, infill percent and layer height were changed to improve surface quality and decrease the amount of time it took to print. The final tekoteko was printed with a 0.75 mm nozzle, 0.1 mm layer height, three top, bottom and perimeter layers, one skirt with four outlines, 10% grid infill at 45° and 45° angles, base temperature of 50°C and extruder temperature of 210°C. The slicing technology used on the STL was Simplify3D. The final printed model is in fig. 8 below.





*Figure 8: The final printed model, with supports and skirting*

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#### POST-PROCESSING OF THE MODEL

The surface quality of the printed tekoteko left much to be desired. Layer lines marred the entirety of the model, clogging and stringing mishaps left noticeable marks and remnants of the support structures clung to the legs and underarm of the tekoteko. The light filament colour resulted in an almost blindingly white model which in turn made the designs hard to see. Thus, the need for post-processing was clear. Sanding was carried out on areas with protruding or extra pieces, starting at a low grit and working up. Different stains and finishes were tested on practice models, with brown pigmented stains being used to make the model look more similar to the original carving and red paint and dye being tried in recognition of the traditional red ochre paint *kōkōwai*, often represented as a Resene “Pohutukawa” red on marae. Some of the different effects created are shown below (fig. 9).



*Figure 9: Practice models coloured with Rit “Scarlet” Dye (left), Wattyl “Walnut Brown” Pigmented Stain (centre) and Resene “Pohutukawa” paint (right)*

The final tekoteko was coloured with Feat Watson’s “Jarrah”, a reddish-brown pigmented stain, and had *pāua* pieces added to the eyes as a reference to the original piece, as well as to Māori carvings in general.

## RESULTS, OUTCOMES AND DISCUSSION



Figure 10: The final Tekoteko, stained with “Jarrah” and with added Pāua eyes

The final tekoteko stands at 18 cm, painted in a brownish-red tint courtesy of Feast Watson’s “Jarrah” stain. The trophy will have a plaque attached to it with the name of the award, “He Tohu Maumahara ki a Paora Mato”, and another for the names of the recipients on it. The tekoteko will be given to the “Hīkoi in Hune” group as a trophy to be used in future competitions. The final STL file is included in the appendix of this report as another key outcome of this internship.

The creation of this tekoteko is a fascinating milestone for te ao Māori, and poses many questions about traditional tikanga and contemporary Māori art. Although not the first “whakairo” made by the method of 3D printing, artist Kereama Taepa for one has had exhibitions featuring 3D printed wheku and taonga puoro (Taepa, 2017), this may be the first *reproduction* of a traditional Māori carving in this way, or at least the first recorded. This process of scanning and 3D printing could be used on old carvings to preserve a tangible impression of whakairo that would otherwise be lost to time. Replicas of famous carvings could be made for museums so that the originals could be returned to their homes and people. It could also be used as a base for new contemporary Māori art. Keep in mind, however, that 3D printing can not be a replacement for traditional carving. Though the end result may look similar, the process of 3D printing is inherently antithetical to traditional whakairo or carving methods. The word “whakairo” comes from the observation of insects such as maggots or “iro” eating away at flesh in the same way a chisel would wood and leaving patterns on the bones (Taepa, 2017). Carving is thus defined as a reductive art, Rautangata (2014) stating that “carvers remove mass to create form”, while 3D printing is an additive art, meaning it *adds* mass to create form. Taepa (2017) calls this process “whakapī”, referring to the “pī” or honeybee’s additive manufacture of their beehives. In the report written for Ngā Pae o te Māramatanga it was called “tā ahunga toru”, applying designs in three dimensions. The fact that it is a completely different process to carving regardless means that the final objects are different, at least physically and spiritually if not externally, as well. It also means that the tikanga associated with it must be different too, though some remain fairly constant across most processes. Karakia is always an important part of any process and is usually carried out at the beginning and end. Food, being “noa” and also a possible contaminant, should be kept away and tools used to make the material or tekoteko such as the coffee grinder should not be used for food afterwards. It is interesting to note that, with the exception of karakia, many of the tikanga commonly adhered to are already being carried out in the labs as part of health and safety. Perhaps it should not come as such a surprise since “tikanga” within itself is simply a set of rules and processes designed to keep people safe.

Another significant part of the tekoteko is the material used to make it. Polylactic acid, or PLA, is a biodegradable plastic derived from plant sugars (Bhagia et al., 2021). In combination with harakeke, a plant whose leaves are traditionally used for weaving, a material with increased mechanical properties is produced that is completely biodegradable and more environmentally friendly than conventional plastic filaments (Stoof et al., 2017).



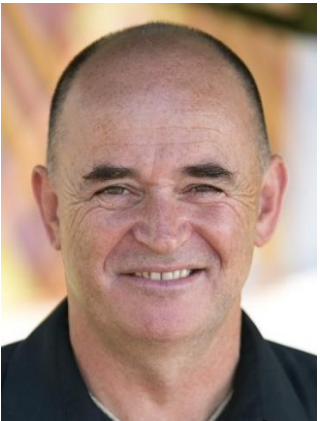
### WAIKAURI GREENSILL

He uri a Waikauri Greensill nō ngā wai o Whaingaroa, Tainui Āwhiro, ngunguru te ao, ngunguru te pō, waihoki nō te whenua o Hauraki, he aute te āwhēa. Ko Ngāti Koata, Ngāti Tara Tokanui me Ngāti Porou ōna hapū. He hua ia o te whawhai mō te reo, i tipu ake i te reo Māori mai i te Kōhanga Reo ki te Kura Kaupapa tae noa ki te Wharekura. Kei Te Whare Wānanga o Waikato ia ināianei e whai ana i te ara pūtaiao, e whakaoti ana i tōna tohu Pūhanga Mātai Matū me te Koiora. Ko tōna tino pūmanawa te whai i te mātauranga. Ā tōna wā kei te hiahia ia ki te mahi rangahau mō ngā rākau Māori, mō ngā pūtaiao Māori me ngā kaupapa maha atu anō.



### KIM PICKERING

He mātanga pūtaiao matū a Toihuarewa Kim Pickering. Neke atu i te 30 tau ia e mahi ana hei kairangahau, kua puta i a ia nui ake i te 100 pepa arotake aropā, e ono ngā mana waihanga, nui ake i te 8,800 ngā tohutoro hoki. Ko ia te kaitohu o te rōpu “Waikato Centre for Advanced Materials and Manufacture”, ko ia hoki te kaiārahi o te “Polymers and Composites Research Group” ki Te Whare Wānanga o Waikato mai i te tau 2000. I whakawhiwhia ia ki te “RJ Scott Medal” mai i te Royal Society of NZ mō te whai pānga nui o ōna mahi ki te hanga matū toitū, he mema hoki ia o “Engineering New Zealand” me “IoM3”. I tēnei wā, e ārahi tahi ana ia i te rōpu “NSC”, e rangahau ana i te te tā matū ahunga whā, e ārahi hoki ana i te kapa o “Āmiomio Aotearoa: A Circular Economy for the Wellbeing of NZ”.



### TE TAKA KEEGAN

He Ahorangi Tūhono a Te Taka Keegan mō te ranga Rorohiko, he Ūpoko Tūhono Māori mō te ranga Hauora, Pūhanga, Rorohiko me te Pūtaiao ki Te Whare Wānanga o Waikato. Kua whai wāhi ia ki ngā kaupapa maha e hāngai ana ki te reo Māori me te hangarau, hei tauira, te kohinga Māori Niupepa, Te Kete Ipurangi, te “Microsoft keyboard”, “Microsoft Windows” “Microsoft Office”, “Moodle”, me te “Google Web Search” ki te reo Māori, “Google Translate”, te “Māori Macroniser” me te “SwiftKey” mō te Māori anō hoki. I whakawhiwhia ia ki te “Māori/Indigenous Excellence Award for Research” mai i Te Whare Wānanga o Waikato i te tau 2013, i whakawhiwhia hoki ki te “Prime Minister’s Supreme Award for Tertiary Teaching Excellence” i te tau 2017. Ko ōna aronga rangahau matua ko te urungi Māori, ngā hangarau reo Māori, ngā tāhono reo taketake me ngā tāhono reo rua. Ko tōna aronga rangahau matua o nāianei te whakamahinga o te reo Māori ki ngā taiao hangarau.