Designing for STEM with Maker Motes: Citizen Science with low-cost environmental sensors

18th UNESCO Asia-Pacific Programme for Educational Innovation for Development

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Numeracy and graphical literacy are often taught in schools in the ASEAN region, South Asia, and East Asia, in a de-contextualised, didactic manner, thus leading to surface-level skill competency without deep understanding of the foundational mathematical concepts undergirding the analysis and representation of empirical data.
SDG 4

... the quality of education has been neglected in educational discourse ...

Director Kim
explicit.
- most curriculum approaches focus here

tacit.
- beyond the control of traditional curriculum / instruction
- immersive environments and sandboxes as a shared proxy lived experience
Hattie’s (2009) “visible learning”

• The child brings to school factors which affect the outcome of schooling

• Students have to be placed at the centre of the teaching-learning process and the teacher has a critical role in doing precisely that

Prof Manzoor Ahmed
• Numeracy, graphical literacy and empirical investigations can be more authentic by using data from within environments already familiar to the learners

• We use open-source hardware and software to obtain and represent local micro-climatic data, as a scaffold towards learners’ numeracy and graphical literacy
Challenges in developing graphicy and data literacy

### Pollutant Concentrations

**Readings on 23 Jun 2013**

<table>
<thead>
<tr>
<th>Region</th>
<th>24-h Sulphur dioxide (µg/m³)</th>
<th>24-h PM10 (µg/m³)</th>
<th>1-h Nitrogen dioxide (µg/m³)</th>
<th>8-h Ozone (µg/m³)</th>
<th>8-h Carbon monoxide (mg/m³)</th>
<th>24-h PM2.5 (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>24(15)</td>
<td>127(86)</td>
<td>44(-)</td>
<td>100(42)</td>
<td>2.3(23)</td>
<td>77</td>
</tr>
<tr>
<td>South</td>
<td>25(15)</td>
<td>134(92)</td>
<td>73(-)</td>
<td>34(14)</td>
<td>1.5(15)</td>
<td>92</td>
</tr>
<tr>
<td>East</td>
<td>19(12)</td>
<td>111(81)</td>
<td>73(-)</td>
<td>45(19)</td>
<td>0.8(8)</td>
<td>85</td>
</tr>
<tr>
<td>West</td>
<td>28(17)</td>
<td>149(96)</td>
<td>45(-)</td>
<td>105(45)</td>
<td>1.4(14)</td>
<td>97</td>
</tr>
<tr>
<td>Central</td>
<td>15(9)</td>
<td>111(81)</td>
<td>22(-)</td>
<td>70(29)</td>
<td>0.9(9)</td>
<td>71</td>
</tr>
</tbody>
</table>

**Note:**
- Figures in brackets are the PSI sub-indices.
- Sub-index for nitrogen dioxide is reported only when the 1-hour concentration exceeds 1130 µg/m³.
- There is no sub-index for PM2.5.

### 3-hr PSI Readings from 12AM to 11.59PM on 23 Jun 2013

<table>
<thead>
<tr>
<th>Time</th>
<th>12AM</th>
<th>1AM</th>
<th>2AM</th>
<th>3AM</th>
<th>4AM</th>
<th>5AM</th>
<th>6AM</th>
<th>7AM</th>
<th>8AM</th>
<th>9AM</th>
<th>10AM</th>
<th>11AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-hr PSI</td>
<td>91</td>
<td>90</td>
<td>88</td>
<td>89</td>
<td>93</td>
<td>93</td>
<td>99</td>
<td>104</td>
<td>106</td>
<td>105</td>
<td>101</td>
<td>96</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>12PM</th>
<th>1PM</th>
<th>2PM</th>
<th>3PM</th>
<th>4PM</th>
<th>5PM</th>
<th>6PM</th>
<th>7PM</th>
<th>8PM</th>
<th>9PM</th>
<th>10PM</th>
<th>11PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-hr PSI</td>
<td>83</td>
<td>80</td>
<td>78</td>
<td>78</td>
<td>77</td>
<td>77</td>
<td>76</td>
<td>75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Hourly updates of 3-hr PSI readings are provided from 12am to 11.59pm. The 3-hr PSI readings are calculated based on PM10 concentrations only.
• It is important to address the lack of context and didactic presentation of codified and symbolic data because such representations are not intelligible to novice learners.

• The lack of context results in a lack of authenticity in the learning experience, which – in turn – does not lead to enduring understanding of the concepts.
Addressing such challenges with a wireless mesh of open-source sensors
Reading the sensor data

• Raw data is in CSV format
• Open in Excel, or export to Google Sheets for collaborative work
The Disciplinary Intuitions / Maker Motes system
The Disciplinary Intuitions / Maker Motes system
The Disciplinary Intuitions / Maker Motes system
The Disciplinary Intuitions / Maker Motes system

What? When? Why?
Visualizing the sensor data
The Disciplinary Intuitions / Maker Motes system

Where?

What? When? Why?
The Disciplinary Intuitions / Maker Motes system
<table>
<thead>
<tr>
<th>No</th>
<th>Sekolah</th>
<th>Topik</th>
<th>Waktu Pelaksanaan</th>
<th>Hari</th>
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<tbody>
<tr>
<td>1</td>
<td>Lab School</td>
<td>Adaptasi</td>
<td>Mulai 5 Sep 2016</td>
<td>Rabu 07.00</td>
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<tr>
<td>2</td>
<td>SMP 12</td>
<td>Ciri-ciri makhluk hidup</td>
<td>Sep 2016</td>
<td>Selasa 07.00, Rabu 9.40</td>
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<tr>
<td>3</td>
<td>SMP 1 Lembang</td>
<td>Objek IPA dan Pengamatannya</td>
<td>Mulai 5 Sep 2016</td>
<td>Senin 8.30, Selasa 07.00, Rabu 07.00</td>
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<td>4</td>
<td>SMP 2 Lembang</td>
<td>Perubahan wujud</td>
<td>Oktober 2016</td>
<td>Rabu 10, Kamis 7.40</td>
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<tr>
<td>5</td>
<td>SMP 3 Lembang</td>
<td>Fotosintesis</td>
<td>Oktober 2016</td>
<td>Senin 10.20, Selasa 07.00</td>
</tr>
</tbody>
</table>
Focused issues of APEC economies

• Use technologies to access equity and equality in education
• Develop teachers with future skills
• Emphasise STEM education

Director Kim
Areas of focus of education reform in Thailand

• Develop curriculum and learning process
• Train and develop teachers and education personnel
• Promote digital technology for education

H.E. Gen. Ratanasuwan
Thank you 😊

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• http://sites.google.com/site/disciplinaryintuitions/
• @thinkermaker